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CONTRIBUTORS TO THE WORK

Alexander C. Abbott, M.D.
Isaac A. Abt, M.D.
Sir Clifford Allbutt, M.D.
James M. Anders, M.D.
John F. Anderson, M.D.
Lewellys F. Barker, M.D.
Joseph C. Bloodgood, M.D.
George Blumer, M.D.
Sir Lauder Brunton, M.D.
Charles W. Burr, M.D.
Richard C. Cabot, M.D.
James Carroll, M.D.
John G. Clark, M.D.
Rufus I. Cole, M.D.
Warren Coleman, M.D.
Matthew H. Cryer, M.D.
Clinton T. Dent, M.C.
Francis X. Dercum, M.D.
G. E. deSchweinitz, M.D.
George Dock, M.D.
Isadore Dyer, M.D.
David L. Edsall, M.D.
Wm. A. Edwards, M.D.
Arthur W. Elting, M.D.
John M. T. Finney, M.D.
Charles H. Frazier, M.D.
M. Howard Fussell, M.D.
Thomas B. Futcher, M.D.
John H. Gibbon, M.D.
Joel E. Goldthwait, M.D.
Samuel McC. Hamill, M.D.
Hobart A. Hare, M.D.
Charles Harrington, M.D.
Ludvig Hektoen, M.D.
Albion W. Hewlett, M.D.
Guy Hinsdale, M.D.
Guy L. Hunner, M.D.
Chevalier Jackson, M.D.
Henry Jackson, M.D.
Theodore C. Janeway, M.D.
John H. Jopson, M.D.
A. O. J. Kelly, M.D.
Maynard Ladd, M.D.
Egbert LeFevre, M.D.
James Hendrie Lloyd, M.D.
G. Hudson Makuen, M.D.
Charles F. Martin, M.C.
Edward Martin, M.D.
Charles H. Mayo, M.D.
William J. Mayo, M.D.
Alexius McGlannan, M.D.
R. Tait McKenzie, M.D.
Herbert C. Moffitt, M.D.
Jesse M. Mosher, M.D.
B. G. A. Moynihan, M.S.
George P. Müller, M.D.
John H. Musser, M.D.
Edward O. Otis, M.D.
Henry K. Pancoast, M.D.
Roswell Park, M.D.
Richard M. Pearce, M.D.
Charles W. Richardson, M.D.
David Riesman, M.D.
Milton J. Rosenau, M.D.
Joseph Sailer, M.D.
Jay F. Schamberg, M.D.
Henry Sewall, M.D.
Bertram W. Sippy, M.D.
William G. Spiller, M.D.
J. Dutton Steele, M.D.
Alfred Stengel, M.D.
Charles G. Stockton, M.D.
James E. Talley, M.D.
E. W. Taylor, M.D.
James Tyson, M.D.
George H. Weaver, M.D.
J. William White, M.D.
Alfred C. Wood, M.D.
Horatio C. Wood, Jr., M.D.

A HANDBOOK OF PRACTICAL
TREATMENT

BY MANY WRITERS

EDITED BY

JOHN H. MUSSER, M.D., LL.D.

PROFESSOR OF CLINICAL MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA

AND

A. O. J. KELLY, A.M., M.D.

LATE ASSISTANT PROFESSOR OF MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA

VOLUME I

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PHILADELPHIA

TO

HORATIO C. WOOD, M.D., LL.D.,

EMERITUS PROFESSOR OF MATERIA MEDICA, PHARMACY, AND GENERAL THERAPEUTICS IN THE UNIVERSITY OF PENNSYLVANIA;

A PIONEER IN THE SCIENCE OF THERAPEUTICS AND A MASTER OF ITS ART;

AN EMINENT AND FORCEFUL TEACHER;

THESE VOLUMES ARE AFFECTIONATELY

DEDICATED

BY HIS PUPILS, FRIENDS, AND ADMIRERS,

THE EDITORS

PREFACE

There is in medicine an art and a science—each mutually dependent on the other. The practising physician's chief concern, however, is with the art rather than the science: his preëminent function, from the patient's point of view at least, is to preserve or prolong life and to mitigate suffering; his major interest, in a broad sense, is centered in the practical treatment of disease, all else that conduces thereto—etiology, pathology, diagnosis—being tributary, a means to an end. Conscious of these facts, we venture to offer to the practising physician, for his consideration and guidance, this Handbook of Practical Treatment, hoping that he may find it helpful and resourceful and a repository of the best, most modern and advanced views in regard to the management of diseased states.

The fore part of the work is devoted to a discussion, from a general viewpoint, of various therapeutic measures; the latter part, to the special treatment of the many general and local diseases. The subjects discussed from a general viewpoint comprise prophylaxis, diet, drugs, rest, exercise, massage, mechanotherapy, psychotherapy, hydrotherapy, balneotherapy, climatotherapy, aërotherapy, electrotherapy, and radiotherapy, as well as other miscellaneous, well-known and justly prized therapeutic measures; but, in addition, emphasis has been laid upon certain sorts of specific therapy, which, resulting directly from painstaking scientific study and investigation, especially in the domain of pharmacology and chemistry, have enhanced the art of medicine and materially augmented the resources of therapeutics—such as organotherapy, serum therapy, bacteriotherapy, vaccine therapy, and chemotherapy. Thus, while the brilliant therapeutic results of the empiricism and clinical observation of the past have been given their due measure of credit, we have aimed to have reflected throughout the work those notable changes and advances in therapeutics that have resulted directly from the application of its science to its art. Drugs, although of material value and often of much importance, are no longer the chief reliance in the management of disease—and rightly: and this because of the uncertainty of the action of many drugs and the difficulty often experienced in estimating accurately their assumed effects. Increasing attention is now devoted to etiologic factors, to dietetic regulations, and to physiologic methods of treatment; a continuous search is maintained for specific remedies; and earlier and more opportune recourse is had to surgical intervention in many disorders that the physician must recognize are amenable to operative rather than to medicinal methods. These changes and advances in therapeutics have considerably benefited the patient—the one most concerned, since the successful application of any plan of physiologic therapeutics implies a study of the patient rather than of the disease. This is true also of surgical therapeutics, the success of which depends not

only upon opportune intervention, but also upon a thorough knowledge of the patient's constitution and reactions rather than upon a mental picture of the assumed lesion; a disregard of the patient in general is only too often followed, not only by no improvement, but also by post-operative neuroses and psychoses. To some extent an innovation, therefore, we have had introduced a discussion of the surgical aspects of the treatment of certain borderland and other diseases; in many instances this discussion is participated in by a physician and a surgeon, so that the reader may have the benefit of the points of view of both. One caution in regard to the surgical treatment of these borderland cases seems desirable: it is that which follows from the fact that surgical intervention is often thought, and is sometimes taught, to be a simple matter—one in which the veriest tyro may engage with confidence, whereas in reality it demands much clinical experience and long training in the experimental laboratory and the operating theater; and assuredly operations should not be lightly undertaken nor by those incompetent to make a diagnosis.

While due consideration has been given to these major matters, a chapter has been devoted to slight ailments and symptomatic disorders, which often command much of the general practitioner's time and consume his patience. This chapter was conceived with a full consciousness of its bearings and importance; and it was undertaken and prepared with a due regard of the exigencies of such cases and of the disastrous results that too often attend not making or not attempting an accurate and complete diagnosis. We venture to believe, therefore, that it will commend itself to the large body of physicians engaged in general practice.

In general, an effort has been made not to overburden the several discussions by citing a multiplicity of methods of treatment and presenting to the reader the embarrassment of choice; only those methods of treatment have been described which the several authors, relying largely upon their own experience, believe to merit the confidence of the profession, as being the best, most efficacious, and most modern. An effort has also been made to avoid or minimize duplication of subject matter and discussion; but some duplication was inevitable. This, perhaps to some extent a defect, possesses the counterbalancing merit of affording the reader the benefit of the opinions and experiences of more than one writer, which seems to be especially valuable in relation to controversial matters and borderland—medico-surgical—subjects.

We have been singularly fortunate in our associates and collaborators. They will be generally recognized as men of wide experience, each a master in his chosen field of work; their names alone are sufficient guarantee of the excellence and authoritativeness of the text; without their aid and cordial coöperation this undertaking could never have been brought to a successful issue. The merit of the work is theirs; ours, merely the guiding hand.

John H. Musser,
A. O. J. Kelly.

Philadelphia, Pa.

CONTRIBUTORS TO VOLUME I

ALEXANDER C. ABBOTT, M.D.

Pepper Professor of Hygiene and Bacteriology in the University of Pennsylvania, Philadelphia

JOSEPH COLT BLOODGOOD, M.D.

Associate Professor of Surgery in the Johns Hopkins University; Associate Surgeon to the Johns Hopkins Hospital; Chief Surgeon to St. Agnes's Hospital, Baltimore

GEORGE BLUMER, M.D.

John Slade Ely Professor of the Theory and Practice of Medicine, and Dean of the Yale Medical School, New Haven

SIR LAUDER BRUNTON, BART., M.D., D.SC., LL.D., F.R.C.P., F.R.S.

Consulting Physician to St. Bartholomew's Hospital, London; Formerly Lecturer on Pharmacology and Therapeutics in St. Bartholomew's Hospital Medical School

CHARLES W. BURR, M.D.

Professor of Mental Diseases in the University of Pennsylvania; Neurologist to the Philadelphia General Hospital

RICHARD C. CABOT, M.D.

Assistant Professor of Medicine in the Harvard Medical School, Boston

WARREN COLEMAN, M.D.

Professor of Applied Pharmacology in the Cornell University Medical School, New York

GEORGE DOCK, M.D.

Professor of Medicine in the Washington University Medical School, St. Louis; Visiting Physician to the City Hospital, St. Louis

DAVID L. EDSALL, M.D.

Professor of Medicine in the University of Pennsylvania, Philadelphia

M. HOWARD FUSSELL, M.D.

Assistant Professor of Medicine in the University of Pennsylvania; Consulting Physician to the Medical Dispensary of the Hospital of the University of Pennsylvania; Physician to St. Mary's, St. Timothy's, and the Chestnut Hill Hospitals, Philadelphia

CHARLES H. HARRINGTON, M.D.

Late Professor of Hygiene in the Harvard Medical School, Boston

LUDVIG HEKTOEN, M.D.

Professor of Pathology in the Rush Medical College, in Affiliation with the University of Chicago; Director of the Memorial Institute of Infectious Diseases, Chicago

GUY HINSDALE, A.M., M.D.

Lecturer on Climatology in the Medico-Chirurgical College, Philadelphia; Secretary of the American Climatological Association; Fellow of the Royal Society of Medicine, Great Britain

MAYNARD LADD, M.D.

Instructor in Pediatrics in the Harvard Medical School; Assistant Physician to the Children's and the Infant's Hospitals, Boston; Consulting Physician to the Boston Nursery for Blind Babies

R. TAIT MCKENZIE, M.D.

Professor of Physical Education in the University of Pennsylvania, Philadelphia

J. MONTGOMERY MOSHER, A.M., M.D.

Clinical Professor of Insanity, Neurology, and Electrotherapeutics in the Albany Medical College; Attending Specialist in Mental Diseases to the Albany Hospital

GEORGE P. MÜLLER, M.D.

Associate in Surgery in the University of Pennsylvania, Philadelphia

JOHN H. MUSSER, M.D.

Professor of Clinical Medicine in the University of Pennsylvania; Physician to the Hospital of the University of Pennsylvania and the Presbyterian Hospital, Philadelphia

HENRY K. PANCOAST, M.D.

Lecturer on Skiagraphy in the University of Pennsylvania; Skiagrapher to the Hospital of the University of Pennsylvania, Philadelphia

HENRY SEWALL, PH.D., M.D.

Visiting Physician to the Denver County and St. Luke's Hospitals, Denver

JAMES TYSON, M.D., LL.D.

Emeritus Professor of Medicine in the University of Pennsylvania; Visiting Physician to the Pennsylvania Hospital, Philadelphia

HORATIO C. WOOD, JR., M.D.

Professor of Pharmacology and Therapeutics in the Medico-Chirurgical College, Philadelphia; Second Vice-Chairman of the Committee of Revision of the United States Pharmacopœia

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PRACTICAL TREATMENT

THE FUNDAMENTAL PRINCIPLES OF THERAPEUTICS

By John H. Musser, M.D., LL.D.

The primary duty of the physician is to preserve life. His secondary duties are to prolong life, to assist nature in her efforts to readjust any departure from the normal in structure or function, and to relieve suffering.

Life is the expression of function. The organism which is in perfect equilibrium with its environment and has all its parts in equilibrium is in a state of health. A state of absolute health must be considered as that condition in which there exists such perfect adaptation of the cells of the organism to their environment, individually and collectively, that a perfect correlation of their various functions results. Any disturbance of such equilibrium, and hence any departure from the normal in structure or function, is a state of disease. But disease, to the therapeutist, means not only this disturbance of equilibrium, but includes, necessarily, the cause of the disturbance. It is, unfortunately, a common habit to disassociate the two. The result of this is a classification based largely on prominent symptoms and the more evident pathologic changes. Such classification keeps up the old idea that disease is a special "something" within the organism, the casting out or the removal of which is brought about by a special method adapted to each cause. It tends to separate the cause and the effect, the combination of which means the disease. While the causes which disturb the equilibrium of the organism are multiple, the effects, which are the reactions of the organism to the cause, are few in number. One can say confidently that these effects are uniform and occur in obedience to general biologic laws. Moreover, any deficiencies, excesses, or aberrations of the reaction are as likely to be dependent upon the individual organism as upon the causal factor. Hence not only the intensity of the cause, but the state of the organism, determines the varying expressions of disease. It will be seen, later, that it is essential in the treatment of an ailing person to determine the cause of the ailment and the degree of reaction of the organism. In fine, it must be an estimation of the degree of health of the organism and the defenses it has put in action to overcome the cause of disease. The reaction is not a process requiring specific remedies for

its treatment; it is a biologic manifestation requiring biologic methods for its guidance and control. Specific treatment, on the other hand, is the treatment of the known cause.

The older physicians, if we interpret their belief from their action in the practice of therapeutics, had no realization of man's relation to the biologic world. Man was set apart from other organisms. With the change in teleologic notions man has been removed from this high estate. He is subject to the laws which govern all life. An organism of the highest type, with highly specialized organs and functions, his birth, development, decay, and death are subject to the same laws of biology that pertain to the most elementary forms of life.

The first general biologic law or general attribute of living matter is that of self-preservation. The first biologic acts of living protoplasm are, therefore, nutritional. Food and its assimilation are essential to its existence. Elimination follows appropriation and assimilation. The organism realizes its need for food by sensory impressions. A little more highly specialized or further advanced in development, it is sensitive to the action of environment, and hence detects the presence of danger by means of its sensory apparatus. In order to obtain food and to remove itself from dangerous environmental conditions, motion becomes necessary, and is the next quality that obtains in matter. These are the primary attributes of life.

Perfect health, in which appropriation, assimilation, and elimination are complete, and in which motion and sensation are highly developed, is the state in which life should be continued during its usual period. As differentiation and development proceed beyond the vegetative stage from simple to complicated aggregations of cells, not only do the dangers from the action of environmental factors increase, but also aberrations in the more highly developed mechanism of the body appear.

The life of an organism, if not disturbed by unusual internal or external agencies, proceeds from birth to its highest development of structure and function by a process of evolution. Thence, in accordance with the universal law applying to all life, it declines by a process of involution to senility and death. The process is physiologic. Senility is the sum of environmental reaction upon the organism. In those in whom there have been few disturbances of equilibrium, or, perhaps, none at all, the acme of this condition may be obtained with only the evidence of ordinary wear and tear in the structures—the end of life coming without any suspicion of environmental antagonisms. Ordinarily, an organism does not have such fortunate existence. Agencies within and without disturb the equilibrium. In consequence, on the one hand, there may be immediate dissolution, or, on the other hand, disease, resulting in death or in continuous disturbances of the processes of life, as in chronic disease, or in recovery.

In the lower and simpler organisms destruction of the entire organism is necessary to cause death. In the higher and more complex

organisms the destruction of a single part or the obliteration of a function, if it be essential to life, is sufficient to cause death.

The destruction of life may be immediate. The agent in sudden death may be mechanical or physical, and from without, as by trauma, lightning, electricity, heat, and cold; chemical, as by an inorganic poison; and biologic, as in ptomain-poisoning and death from snake venom. The cause may arise within the organism, as in acidosis, uremia, or as, possibly, a perversion of internal secretion, as in exophthalmic goiter or in Addison's disease. An immediate cause may be the rupture of a vessel, as in the brain; a block in a vessel, as the coronary artery; an obstruction of the intestinal tube. The difference between the action of the agency from without and that within is that the latter has been preceded, whether evident or not, in nearly every instance by definite organic change. We have, it is true, those rare instances where shock without the existence of previous disorder causes death from mechanical insult; rarer still are those instances seen, for example, in acute thyroidism, in which shock is due to psychic insult.

The overwhelming action of the destructive agent in all these instances, or the lowered resistance of the organism, on account of which immediate death occurs, excludes all efforts at preservation. Hence the office of the physician under such circumstances is of little avail.

Similar or allied agencies, in lessened force, produce a disturbance of equilibrium of less degree, which may end in partial recovery, in complete recovery, or in death. The outcome depends in part, at least, upon the action of the physician. The preservation and the prolongation of life and the freedom from suffering are obtained by restoring entirely or in part the normal equilibrium.

The environmental agencies which tend to cut life short or to excite disease and thus cause suffering, are met by reactions in the organism which bring about an adjustment of the disturbed equilibrium. Such reaction is physiologic, and is not a departure from that normal reaction which occurs between the organism and its environment, save in the intensity of the process. By this reaction the organism protects itself—it expels, destroys, neutralizes, or antagonizes the agent.

Biology teaches the various modes of defense that living protoplasm, throughout all its variations, possesses. In the lower animals such mode of defense is a part of instinct, of "that inherent, unconscious intelligence, a faculty which is constant in its operation and, though not inerrant, is free from the vacillations and failures of human reason" (Burroughs). It is well said that the lower animals are wise in order to survive and perpetuate species, but that outside of that sphere they are usually stupid. The high specialization of those senses by which the enemy can be deceived—the color, the form, the habitat, special secretions, the mode of storing food, are all biologic methods of defense. Throughout the entire biologic world these factors are operative. Thus, preservation of life is the

inevitable result of natural law. In man, to the stimulus of instinct is added that of reason. However, when one sees the blundering attempts to aid preservation, notably in typhoid fever and other infections, one need not hold reason in such high esteem or feel complimented by the action of this higher attribute of man. If reason, however, is to be exonerated, then man is culpable.

The defense is set up alike against inorganic as well as organic elements. The little mass of protoplasm that is washed by the waves, subjected to changes of temperature or to the attacks of other forms of protoplasm, has powers of defense as well defined as the highest aggregations of protoplasm subjected to allied antagonistic environmental conditions. As the organism becomes more highly specialized, the modes of defense are more highly specialized. The various agents which aim to destroy human life or bring about the state known as disease are met by an augmentation of those modes of defense which are present in health.

As the essential attributes of life make for longevity, they become, when there is loss of equilibrium, as in disease, the strongest means the organism can possess for self-preservation. It follows then that the greatest defense the organism possesses is that correlation of cellular activities which is manifested in perfect health, and that that organism in which appropriation, assimilation, and elimination are perfect, and in which motion and sensation are highly developed, is the one in which life will be continued its usual period, and which has the best defenses against its enemy—disease.

Proper nutrition results in strength and resistance of the organism. Metabolism is attended by chemical processes which readily become active processes in the change of poisons—biologic or inorganic—into innocuous materials, and which processes aid in maintaining the temperature of the body. An increase of cellular activity brings about fever—one of the most important means of defense. The same nutritional and assimilative act causes an increase of the white cells of the blood—leukocytosis—another mode of defense of the organism. The increased nutritional processes stimulate secretory activity and thereby multiply the abundant resources of the organism, which are its "factors of safety," to be referred to later. In consequence thereof there arise to an increased degree the chemical processes which are essential in the defense of the organism. Insult of the nervous system causes pain, another mode of defense. Motor insults seen in muscle spasm, whether of voluntary or involuntary muscles, resulting in vomiting, diarrhea, cough, spasm of the ocular muscles or other similar muscles, spasm and resistance of the skeletal muscles, are modes of defense—an exaggeration of the normal physiologic acts.

The agencies which have disturbed the equilibrium and produced a departure from the normal in structure may have been met by well-organized defense. The result of defense, when local, as in inflammation, may be, not resolution, but a continuance of the

process, terminating in deformity, with, at first, thickening or enlargement and afterward contraction, causing, in the case of tubes or channels, an obstruction, or in the viscera, degenerations or fibrous overgrowth. Under such circumstances we find evidence of secondary defense, that is, attempts to approximate the normal equilibrium by the adaptation of the organism to the morphologic changes. This is seen in the establishment of collateral circulation after vascular obstruction, in the occurrence of hypertrophy of the heart as the result of a valvular lesion, or hyperplasia of a kidney when the opposite kidney has been destroyed. The effort of adaptation brings about what is known as compensation or adjustment. One of the most effective agencies for adaptation, as well as defense, is the overwhelming provision against loss that is furnished by paired organs and by the multiplicity, far beyond the normal needs of the organism, of the cells furnishing the products of gland secretion. These "factors of safety," as they have been aptly termed by Meltzer, are of the greatest importance in defense against disease.

It is of interest to inquire concerning the expression of the effect of the agents which either temporarily disable, often shorten, or completely destroy life. To rehearse the agencies themselves would be to enumerate all the etiologic factors of disease and dwell upon all the environmental factors, a review not within the province of this discussion. The effects of such agents, inasmuch as they are physiologic and uniform, can be briefly given. An understanding of the fundamental expressions of disease enables one to grasp readily the therapeutic requirements. These expressions are (1) morphologic; (2) physiologic; and (3) those of the reaction to infection.

Morphologic Expressions of Disease.—These may be congenital or acquired. The effects of prenatal deleterious agencies may be seen in the nervous system, the vascular system, and the osseous system. The cause of congenital morphologic conditions is not known. The simplest form may be seen in those osseous aberrations of the face which interfere with breathing or with mastication. A person thus affected undoubtedly has a handicap. All those deficiencies of the organism which are seen in the phthisical type of chest and in ptoses, displacements of the heart and vessels, belong to this class. All these conditions as well as the stigmas of the degenerate, modify methods of treatment.

Acquired conditions are those due to structural weakness, as the visceral ptoses or the dilatations of hollow viscera; to hernia; to obstructions of tubes or channels, as the fauces by adenoids, or the blood-vessels, or the intestinal canal; to cellular aberrations seen in tumors; to morphologic conditions the result of work, as emphysema, cardiac hypertrophy, muscular and skeletal changes; to foreign bodies, etc. Many of these morphologic conditions are a sequence of general or local infections or of trauma. They are likely, however, to shorten life and to cause suffering. Previous illness or injury may have been the cause of many, the influence of which

must be reckoned with in estimating the gravity of the anatomic condition. Similarly, physiologic disorders give rise to anatomic changes, whether a nutritional disturbance, as in rachitis or gout, or a secretory disorder, as in thyroidism.

Physiologic Expressions of Disease.—The physiologic expressions of disease are seen in all those disorders which may be termed (1) functional, metabolic, or nutritional, and (2) perversions of internal secretions. It is convenient to use the term functional, although any disturbance or any act of the organism implies some organic change.

The most pronounced functional expression of disease, and perhaps the most common, is that which is seen in fatigue. A functional or fatigue disease is a condition which tends to shorten life and cause suffering. It is none the less serious because it is without morphologic basis. It is seen in the fatigue neuroses, as neurasthenia; in the states in which the higher centers lose control of the lower centers, as in hysteria. It is seen in the weak heart with its congestion and train of organic visceral changes which occur later. Enfeeblement of the digestive and assimilative processes, with secondary toxemias, gives rise to cardiovascular and elimination disorders. Fatigue and the toxemia associated therewith almost always compel the organism to use stimulants of various kinds, which precipitate that state of the cardiovascular system which is seen in arteriosclerosis. Arteriosclerosis is also caused by intoxications, by infections, and by violent action and reaction attendant upon strenuous efforts. It is, however, unquestionably the result, in a large number of instances, of a fatigue neurosis plus an intoxication with secondary secretory and chemical unbalance. It should be emphasized as an expression of disease, beginning in functional disorder, the progress of which, with its vascular obstructions and secondary degenerations, gives rise to suffering, shortens life, and even to a degree far beyond other agents, causes death.

Weakness of muscles, organic and inorganic, weakness of the osseous structure and of the blood, and insufficiency of secretion and excretion, supply an enormous number of ailments, the determination of the fundamental cause of which weakness is essential in interpreting the cause or scope of any illness.

The known metabolic disorders which are well understood are few in number, but as knowledge advances we find some hitherto obscure ailment to be the result of disturbed metabolism.

The evidence of perverted metabolism is manifested by objective and subjective phenomena. Emaciation or general atrophy and obesity are the perversions recognized by the body-weight. In rachitis there are perversions of growth. In gout and scurvy nutritional changes in structure and secondary inflammatory conditions are seen. Acromegaly, osteitis deformans, pulmonary osteo-arthropathy, are pronounced morphologic expressions of perverted nutrition. The atrophies and hypertrophies of skeletal muscles, as in pseudo-

and true muscular hypertrophy, of weak muscles, as of the eye, are likewise expressions of nutritional deficiencies. In internal organs the degenerations, fatty and amyloid, the hypertrophies and atrophies, are evidences of nutritional perversions, often a part of a general process, but frequently due to local conditions, as a disturbance of the circulation or innervation or both.

Other objective phenomena of nutritional disorder are modifications of the temperature of the body, of the respiratory quotient, of the blood, of the urine, and of feces.

The symptoms of chloro-anemia and of the secondary anemias are examples of the train of functional and organic symptoms which follow in the wake of impoverished blood.

Many of these facts are brought out, for example, by a study of the urine and its normal and abnormal constituents. By this means the auto-intoxications from perverted nutrition are recognized. We thus determine the presence of acidosis, the occurrence of putrefactive processes in the intestine, of glycosuria, and the increase of the purin bodies, as in gout.

The subjective phenomena of impaired nutrition are the result of intoxication, and are seen in the loss of sense of well-being, in the presence of chronic functional nervous disorders, and in the disturbance or impairment of the function of various organs. It is seen to be a fruitful cause of another physiologic expression of disease already referred to above—fatigue. When such fatigue arises, many secondary conditions follow in its train; thus the cardiac weakness leads to diminution in functional activity of other organs. The weakness of digestion which results, multiplies the nutritional deficiencies. The nervous system, perhaps, suffers more from poor nutrition in its wide sense than any other structure, and the long train of local or general phenomena that result is seen in neurasthenia, hysteria, neuralgia, local and general spasmodic affections, and, notably, in psychasthenia, hypochondriasis, melancholia, and, perhaps, a large group of the insanities.

The secondary condition which arises from malnutrition is lowered resistance, in consequence of which the organism is prone to, or unable to withstand, infections. The well-known experiments of Trudeau show the effects of bad environment on the organism, and resultant susceptibility to infection. The inheritance of a weakness or of impaired nutritional states is often the result of inheritance of a morphologic state. The stocky individual usually has good resistance. The one with the paralytic type of thorax and ptoses of internal viscera has poor resistance. The latter arises because, in the displacement of viscera, there is interference with function, and this almost always means mal-assimilation.

The chemical correlations necessary for proper metabolism, the destruction or the neutralization of metabolic products, of bacterial products, and of the toxic materials introduced with food, and those associated with the internal secretions, are so extensive as to forbid

consideration in these pages. It is sufficient to say that complete metabolism and perfect nutrition mean a coördination of the activity of the glandular organs as well as of the cells of non-glandular organisms, such as the subcutaneous connective tissue.

Metabolic disorders and modifications of the internal secretions are the result of a disturbance of chemical correlations. This disturbance is the result of nervous influences, of the diminution, increase or perversion of the food-supply, or of modifications of the oxygen supply to the lungs.

All forms of nerve action are an expression of chemical activity. Our sensations, our emotions, and all impressions from without, produce this activity, which is extended to the organs, modifying their secretions. Modifications of the secretion of one gland disturb the chemical correlations, inasmuch as the hormones, which are chemical messengers, influence the secretion of other glands or stimulate other activities. This is seen in the effect of secretin on the pancreatic, hepatic, and intestinal secretions, or of adrenalin on the circulation. Thus improper food will influence the amount of HCl secreted, and this modifies the action on the duodenal secretion to the end that it is increased, lessened, or impaired, and is thus followed by impairment of the secretion of the organs activated by this substance.

Modifications of nutrition are seen when there is perversion of the sexual glands, the pituitary body, the thyroid, and the parathyroids.

Cells, it appears, cannot act alone. They require an activating substance, which is a ferment or a hormone. Moreover, these substances may inhibit the action of the cells. When a cell has lost the chemical and structural composition necessary for its activity, the making of the ferment or hormone is not interrupted. Other cells take up the manufacture, or the effect of the changed product is neutralized or antagonized by a secretion modified because of the original chemical change. The action of these modified products may explain the varying symptoms seen in disease, and as each individual has individual chemical structure, idiosyncrasy may be also explained. A disease with definite etiology can show various phases, particularly when organs are secondarily affected by toxins. Krehl has pointed out that the absence of or insufficient function of some organ in various persons leads to similar, but in certain respects different, symptoms, especially if the change of function is qualitative. Glycosuria is seen in disease of various glands, as the liver, pancreas, thyroid, adrenals, etc.; hence it is likely that disease of one organ must affect others intimately related. The organs presumably have an interrelation which is necessary for the proper function of all organs. This is illustrated by the effect of burns leading to marked disturbance of internal organs and death. Either a poisonous substance arises from the burn, or, and this is more likely, the influence of the skin on metabolism has been changed, or if protoplasm is broken down, substances are created which affect the thermo-regulating apparatus and cause fever.

Perversions of the internal secretions give rise to many affections which, singly or as complications of other disorders, impair life or cause great suffering. The well-known phenomena of hyposecretion or hypersecretion of the thyroid gland, and perversions of the secretions of the adrenals and of the thymus gland, give rise to well-defined symptoms. These alterations of secretion are not usually attended by morphologic changes which can be readily demonstrated in the affected organ, except in the thyroid gland.

Infections, Infestations, Intoxications.—Inasmuch as an infection is attended by a reaction which is physiologic and by pathologic changes which are anatomic, the changes due to infection might be included under physiologic and morphologic expressions, but on account of the peculiar phenomena of infection and immunity, a third term must be used to designate them. The expression of disease of this type includes: (1) Infections, local and general; (2) the infestations; and (3) the intoxications. A survey of this character, furthermore, is not complete without including the chronic inflammatory processes, the result of infection or intoxication, and the degenerations, associated with acute and chronic inflammation.

Diagnosis.—In this manner we can summarize the various affections against which the organism may have to defend itself. It can readily be seen that one might have begun with the infections and intoxications, proceeding in the reverse order, for they are often antecedent to physiologic disturbances and to anatomic and functional conditions. So, also, the physiologic conditions lead to morphologic and functional disorders. There is, therefore, very often a blending of the processes. It is common to see an infection cause a physiologic disturbance which is followed by a morphologic aberration. For instance, an acute thyroiditis will often cause hyperthyroidism, followed by a hypertrophy of the gland, with or without cyst formation.

If the therapeutist, therefore, asks himself the question, in each case with which he is confronted, is there an anatomic or a physiologic expression of disease, or an infection, an infestation or an intoxication? and, if so, is it a primary or secondary condition? it will enable him to interpret clearly and to direct lines of treatment more effectually. The answer will bring at once to his mind the processes which nature has at her command for defense.

Before any attempt at interference other than "direct" treatment of the cause, an estimate must be made of the reparative power of the organism. This will mean, at once, an inquiry into the nutrition, and hence the resistance of the organism and its capacity for maintaining nutrition, the degree of elimination, and the health value of all the organs of the body.

The Defenses of the Organism.—What defenses and adaptive powers does the organism possess?

Nature defends itself against the various morphologic disorders by (1) expelling a newgrowth or a foreign body; or (2) by surrounding the latter by inflammatory products which render its

presence innocuous; or (3) by overcoming obstruction by hypertrophy; or (4) by the formation of a collateral circulation. The efforts to remove calculi, the vomiting of undigested food, the discharge of foreign bodies from the intestinal canal by diarrhea, from the eye by a flood of tears, from the nose by sneezing, and from the throat and limiting lungs by coughing, are defensive acts.

In functional disorders and fatigue conditions the methods unconsciously resorted to by the organism to bring about repair are rest or exercise, sunlight, fresh air, tonic environmental conditions, and the adaptation of duties to the actual powers of the organism, such as limiting a physiologic act, like digestion, to its capacity.

The Infections.—The reaction of the organism to a local infection is seen in the process known as inflammation. The defensive reaction gives rise to an increased flow of blood to the part, an increase of the leukocytes, and later an increase of the fixed tissues. The increased amount of blood destroys the bacteria and neutralizes the toxins or the ferments; the leukocytes engulf the bacteria or, by their chemical functions, exercise an antitoxic or antifermentative influence; the new tissue walls off, and by mechanical or vital powers, destroys or removes the primary cause, and removes or dissolves necrotic tissue. Leukocytosis, from repeated observation, is a strong means of defense. As pointed out by Adami, it is a defense by adaptation. Fever is another agency of defense in the infections, whether local or general. Clinical* and pathologic evidence shows that fever, if not too high or too prolonged, enables the organism to resist pathologic invasion, and that it attenuates the growth and virulence of many microorganisms. It is an attempt at auto-sterilization. The occurrence of leukocytosis and fever creates antitoxins, bacteriolysins, agglutinins, precipitins, and coagulins—new forces which develop the defense of the organism. Fever or leukocytosis, the course of which is normal for the infection in question, may be looked upon as a healthful reaction of the organism.

The great defense of the organism against infection is the creation of immunity. When established by the organism, it is known as active, when by the physician, as passive, immunity. A discussion of the principles underlying the production of immunity will be found elsewhere.

The infestations may be overcome naturally by the organism, either by expulsion, as in the vermes, or if established in the tissues, by a reactive inflammation which destroys or encapsulates the infestuous agent.

The Intoxications.—They are endogenous and exogenous. The endogenous intoxications are rendered innocuous by the chemical correlations previously considered, by elimination, and by the vicarious action of organs. The product is neutralized, antagonized, or eliminated.

Thus far we are unfamiliar with specific defensive agencies against

* The Uses of Fever; the Danger of Antipyretics. Musser: Medical News, 1892.

alcohol, tobacco, tea, coffee, and allied materials. The only suggestion of defense in these instances is that of toleration. The system tolerates for a time their action, but sooner or later tolerance ceases.

In what manner is the organism defended by perversions of metabolism or of internal secretion? The answer is best given in the words of Meltzer: the overwhelming abundance of structures provided to conduct a single function; the ability of the secretory organ to receive stimuli through chemical or nervous sources, so that one may supplant the other; the likelihood that one group of glands can assume the function of others or new cellular activity replace lost cellular activity elsewhere; the change in character of the products of cellular activity by the new agents, whereby the new excretions or ferments are neutralized or antagonized.

By this adaptability a spontaneous cure is brought about. Increased functioning or a modification in the functioning of other tissues may have an indirect favorable action on the elimination of diseased products. The indirect influence through the chemical action of one organ on other organs is the great defense of the organism in metabolic and secretory disorders. It is here that so-called indirect therapeutics must come into play: to secure healthful action of all the organs and tissues unaffected will modify or mitigate the effects of the diseased structure.

It is thus seen, in accordance with natural law, that the organism is supplied with powers of nutrition which induce resistance, which enable it to protect itself by the destruction, by the counteraction, and by the elimination of deleterious agents, and thus by adaptation provide for the re-establishment of the disturbed equilibrium. It follows, as a scientific ultimatum, that it is the province and the duty of the physician to conserve these forces of nature. Realizing the various properties of protoplasm, one is reminded of the statement of Bigelow: "It is required that the physician safely conduct the patient through disease into health." The physician does not drive out disease, as was believed to be his province in the past, but, rather, he drives in health.

We thus have a modern scientific basis for the familiar Hippocratic dictum "to do good or do no harm." To engage otherwise than in obedience to biologic laws would be meddlesome and harmful. Unfortunately, nutritional, resistant, defensive, and adaptive powers may, for various reasons, not accomplish their purpose. The factors of safety may not be equal to the demands upon them. It is the function of the physician to determine the deficiencies and aberrations and to supply means to aid the organism.

Failure of Defense.—Failure of the defenses of the organism against disease takes place because of the overwhelming action, quantitative or qualitative, of the causal agency. It may also be due to decreased resistance of the organism. Usually the defensive properties are sufficient, provided the organism is in perfect health. In such state, in response to the irritant, the normal forces of the

organism are increased; they are distributed rapidly where needed; the reserve force is sufficient to meet the emergency, or an abundance of new forces is created. On the other hand, the organism may be handicapped by weakness, congenital or acquired, morphologic or functional, by previous disease, by the period of life, or by the environmental conditions.

Congenital conditions are due to some fault, to adopt a term from the geologists, in prenatal life; to the persistence of or the effects of some ancestral affection or some ancestral toxemia. While it is not possible to demonstrate it scientifically, it is not beyond belief that chronic alcoholism influences the resistance of the offspring for many generations. Moreover, it must not be forgotten that family groups have periods of involution, just as the single organism, with early tendency to degeneration, to senility, to lessened functional power, defying the efforts of the physician to prevent, arrest, cure, or even mitigate disease. What physician of experience is there who does not know a family group that has no resistance? another that withstands all infections? The involution type often baffles the efforts of the physician.

Morphologic conditions which are congenital modify to an extreme degree nutrition, resistance, and defense. The physical stigma of degeneracy serves as a handicap to the preserving processes of life. We are all familiar with the train of disorders that attends congenital conditions of the nares when deformed or obstructed. The hypoplasia of vessels, the reversion, as of the blood, to earlier types, notably prevent the action of the defenses. Ptoses of the viscera militate against defense. Acquired conditions, by virtue of the long continuance of vicious habits and bad environment, equally nonplus the physician.

Aids to the Defenses.—The offices of a physician are not specially required by the physiologically and anatomically normal man when he is sick. When, however, there is excess or diminution of the processes of preservation and adaptation; when there is modification of the processes of nutrition, as seen in the impaired metabolic states referred to, the physician's services are definitely needed. After the physician has determined (1) the cause of the affection from which the patient suffers, (2) carefully estimated the morbid processes and the manner and stage of the reactions of the organisms, (3) determined the health value of all the organs and systems of the organism, (4) estimated the degree of suffering, and (5) gathered the facts of the family and racial history and of the personal or social history, including the previous medical history, in short, studied the individual, he can plan a procedure to relieve suffering and facilitate recovery.

Mode of Aid.—It is needless to say that in many cases a judicious *expectancy* is all that is required, and, bearing in mind nature's defenses, it is usually the wise plan to follow.

Treatment may be *direct* or *indirect.*

Direct treatment aims at the cause of the disease, *etiologic* treatment, or at the symptoms of the disease, *symptomatic* treatment.

By the *etiologic* mode of treatment, the cause is removed, neutralized, antagonized, or destroyed. It is the ideal method of treatment. We give quinin to destroy the plasmodium of malaria, and intestinal antiseptics and vermifuges to destroy parasites of that canal. It is not usually necessary to consider the individual, although there are at times qualifying circumstances in connection with the organism which modify our plans of treatment. Thus the state of the secretions or of the gastro-intestinal canal or other circumstances may compel a different dosage than that which is usually given, or a different mode of administration. We may not give the salicylates, which apparently are remedies directed to the cause, in acute rheumatism, because of renal or cardiac complications.

Symptomatic treatment is a phase of humane treatment. All treatment is humane, but when directed specifically to relieve suffering, it is especially deserving of the appellation. It is, however, none the less valuable as an agent for repair or recovery. All suffering means wear and tear of the organism, and within limitations its relief is conservative. Pain induces a shock which may be fatal unless judiciously relieved. While symptomatic treatment is direct, and hence most useful, it also must often be modified or withheld on account of the state of the organism. Morphin often cannot be given to relieve pain in chronic nephritis with insufficient elimination, particularly if the pain arises in the course of an infection, as the pain of pleurisy in pneumonia. It is not an ideal nor altogether a scientific mode of treatment.

Treatment may be *indirect*. If it is not possible to treat the cause, an *indirect* therapy is adopted, a method referred to in the previous pages. The individual is the object of treatment. The organism and its defenses are carefully studied. The state of the organs, those affected and those unaffected, is considered. Insufficiency of function is corrected, and excess of function repressed. Perfect adaptation and perfect defense come from perfect correlation of the functions of all the organs of the body. It is the aim of the therapeutist to bring this about, and hence to conduct the patient by indirect methods to health. The morbid process is also made the subject of study.

Indirect treatment is conducted by methods which are *physiologic* and by methods that are *pathologic*.

Physiologic therapeutics embraces the use of all procedures which sustain life and make for health in the normal organism. The effort is made to stimulate physiologic processes, to repress them when in excess, to direct them into proper channels. It implies the management of the normal forces of the body. It means the direction of nutrition, the management of function by methods which promote them in health. A gland may have deficient or excessive activity, which may be controlled by normal stimuli or

sedatives; if deficient, a similar secretory product may be supplied to the organism, as the thyroid extract; or if in excess, a chemical that may neutralize the excess may be given, as alkalis when there is excess of HCl. Suppression of activity may be gained by cutting off the nerve-supply or the blood-supply, or a part of the structure may be removed.

Pathologic therapeutics aims to imitate nature in the creation or direction in proper channels of new forces. It assists in the formation of new defenses or supplements the normal defenses. Hence we have serum therapy.

The defenses or methods of repair are: (*a*) assisted by employing similar methods; (*b*) restrained or modified when they are in excess. How may we aid the defenses of the organism?

The defenses of the organism may be deficient; they may be excessive; or they may be brought into action irregularly or without that harmony of action of all the organs of the body which is necessary for its highest physiologic action. They require the assistance of man. Hence, as Cabot well says, we must attempt—(*a*) to supplement or imitate nature's efforts; (*b*) to oppose or neutralize nature's efforts; (*c*) to modify, limit, or divert nature's efforts.

It will occur to any one reviewing the functional disorders that following the lead of nature we can aid the defenses of the organism in many, if not all, of the affections which belong to this group.

The fatigue neuroses, local and general, are assisted by rest, by hydrotherapy, by aërotherapy, by selected food, by a judicious psychotherapy, by exercise and massage, by selected pharmacotherapy, and lastly, by indirect therapy, which brings about correlation of function of all the organs. The metabolic or nutritional disorders are assisted by the methods above noted, either by supplying to the organism deficiencies, as the calcium salts, or by cutting out of the supplies substances present in excess, as chlorid of sodium. Here it is that alterations in diet are in many instances the most essential methods. If the internal secretions are in excess, as the thyroid gland, brought about, perhaps, by the effort of the gland to replace some other secretion, we employ rest, cold externally, and indirect therapy, or removal of a portion of the gland; or if deficient, we administer thyroid extract. When the parathyroids are at fault we supply calcium. The physiologic disorders which bring about excesses of motor or secretory function are assisted, controlled, or suppressed. Vomiting, nature's effort to remove irritants, is induced; diarrhea, instituted for similar reasons, is excited; both are repressed when in excess or if they continue when the cause has been removed. Peristalsis is checked or encouraged, as the physiologic needs require. Cough is to be excited to expel a foreign body, controlled to secure rest and conserve strength, or suppressed in the first stages of laryngitis, etc., in accordance with the needs of the organism. Every defense of the organism must be viewed by the therapeutist in this manner.

We aid nature in its defenses against the anatomic expressions of disease by regulating the entire life of the organism so as to bring about adjustment of function or complete adaptation. The daily life must be made to conform with the anatomic departure. Indirect therapeutics and personal hygiene are the modes of securing this end. Assistance is given by supports, as trusses or abdominal bandages; by keeping channels open when the adaptive forces of inflammation have gone too far, as in stricture of a canal. The aid of the surgeon is required in these anatomic conditions more frequently than in any other—to remove calculi the organism cannot expel, and tumors that are not encapsulated or free from anatomic disturbance; to repair excesses or misplacements of adaptive processes, as the removal of adhesions.

The inflammations are aided by the removal of the cause, as bacteria or a foreign body, or of the products, as pus or a gangrenous appendix; by poultices or passive hyperemia to increase the inflammatory edema, in the serum of which ferments, to destroy bacteria and anti-bodies to neutralize toxins, are present; restrained by position, by cold, and by sedative applications, if pain and other symptoms are deleterious to the organism. Nature is also aided by an increase of leukocytes and by encouraging or repressing fever.

Immunity is active and passive. The former is stimulated by injecting killed organisms into the infected subject. The attempt is made to stimulate the powers of the body to greater activity in the production of immunity. Hence vaccination is conducted with success in typhoid fever, especially in preventing relapses, in plague, in cholera, and in local streptococcic, staphylococcic, and bacillus-coli-communis infections. Passive immunity, in which field the great triumphs of serum therapy have been made, is conducted in diphtheria, tetanus, and cerebrospinal meningitis by the injection of the respective antitoxin.

On the other hand, some of the defensive reactions of the organism, as fever, must be controlled, if excessive and harmful. There is evidence that in those infections in which the toxin is liberated from dead bacteria this liberation is increased, and hence the toxemia is increased, by higher temperature. Anything which lessens the toxic production will lessen the toxemia; hence we see the beneficial effects of cold baths in typhoid fever and of quinin judiciously administered, as pointed out by Richardson.

In all the disorders of the economy, nature makes provision for defense. Often it is indirect, as, for instance, rebellion against certain foods when the secretion of hydrochloric acid is absent or increased. The mode of treatment of variations of HCl secretion illustrates the methods by which the organism can be aided. First, if diminished or absent, the supply is augmented by the administration of the acid; if increased, the excess is neutralized by alkalis. At the same time, in the first instance, all those methods which stimulate secretion, as bath, drugs, pleasant environmental conditions, must be employed, and, in the second instance, all those drugs and methods which

repress or neutralize the excess of secretion must be employed: both often can be accomplished by the regulation of diet alone.

It is thus seen that the physician is a biologist, and that the best results must come from the employment of biologic methods in the study of his case. It is necessary not only to determine the degree of suffering and the cause of the suffering, but to note the effects of the disease upon the individual. The careful weighing of the reactions of the organism, of the power of its defense, and the ability for adaptation is essential. To do this and then assist nature where there are deficiencies, to control or neutralize when there are excesses, must be his endeavor.

The *indications* for treatment are based on: (1) The cause of the disease; (2) a true conception of the morbid process; (3) the result of the examination of all the organs of the body; (4) the symptoms; and (5) the facts derived from the family, the social, and the previous medical history. It is well for the practitioner to keep clearly in mind such an outline in order that no elements requiring consideration may escape him. It will enable him thoroughly to treat the patient, independently of the causal agency. To interpret a case in this manner from the standpoint of therapeutics is to employ all agencies at our command which are suitable. In many instances the recognition of the cause will enable us to limit our attempts to etiologic treatment. A true conception of the morbid processes will help us to estimate the defensive and adaptive powers of the organism, not possible, however, without a study of the remaining indications for treatment. How the disease influences the organs not the seat of disease and their power to assist the organism can be learned only by a study of all the organs. The facts of the family, the social, and the previous medical history are as important for treatment as for diagnosis. Herein are considered all environmental agencies for good or ill, the question of stimulants, the influence of age, sex, inheritance, and other factors.

The means which the physician has at his command to further the processes of nature are many. They are:

Hygienic treatment, including the rest treatment; pharmacotherapy; dietotherapy; climatotherapy; psychotherapy; mechanotherapy; hydrotherapy; electrotherapy; thermotherapy; radiotherapy; pneumotherapy; serotherapy; organotherapy; bacterintherapy; and surgical treatment.

The bountiful resources which the therapeutist has at his command and the indications for their use should be familiar to him. It is scarcely to be expected that the practical application of all of them could be conducted by one individual. He would be debarred because of lack of time or because of the inability to acquire the technique of the various methods. The rigorous scientific methods required demand a technique elaborate and painstaking. It follows that, as we advance in our onslaught on disease, specialists in therapeutics will arise, if they have not already arisen. Inasmuch as prevention

goes hand in hand with diagnosis and treatment, a large group of the infectious diseases will fall to the care of the State, in great part at least. With trained technicians in the application of therapeutic measures, as, for example, the surgeons, suffering mankind will receive a corresponding benefit. Just as we now see the internist and the surgeon in co-ordination, so we will see the internist aided by the specialist in involved technique in therapeutics. The control and stimulation which we see in the first instance will attend the second.

It goes without saying that the essential of success in therapeutics is correct interpretation. The attempt to diagnosticate the ailment correctly is of itself a therapeutic measure. If properly conducted, it indicates to the patient interest on the part of the physician, which arouses hope, and it gives evidence of skill which stimulates confidence. To secure these psychic stimulants of the physiologic processes of the patient is to attain a most, if not the most, helpful force in restoring health.

Medicine is a science and an art. The recognition of the cause of disease by instruments of precision and by biologic methods is a science; the interpretation of the effects of the disease is a science and an art. The organism is often unwilling to unfold its processes. It is secretive of the effects of disease. This is especially true of psychic conditions. To extract the secrets, to unfold the mysteries of the various reactions of the organism, requires an art which is in part inherent, as tact is inborn, yet which is in greater part the result of long experience. When the older practitioners fought their battles single handed, without biologic aids, this power of interpretation and treatment was an art, the possession of which, today, should not be disdained. While the possibilities of therapeutics are immensely enhanced by the science of medicine, they have lost something by the tendency to disregard the art of medicine.

PREVENTIVE TREATMENT

By Charles H. Harrington, M.D.

Revised by A. C. Abbott, M.D.

THE GENERAL PRINCIPLES OF PROPHYLAXIS

General prophylaxis may be defined as the science of the prevention of disease. Since prevention of disease involves a knowledge of the manner in which it gains its start and of the conditions which are favorable to its inception and development, it is clear that prophylaxis is inseparably connected with the science of etiology. Without knowledge of the etiology of a disease all prophylactic measures concerning it must necessarily be a mere matter of guesswork, which may or may not be attended by a fair measure of success. For example, until within recent years the true cause of malarial fever was unknown, but, by begging the question, it was for a long time believed that the disease was due, as its name implies, to bad air, to so-called miasms, defined as "morbific exhalations from putrescent matter, animal or vegetable; malarial poison; swamp-gas." A miasm had never been seen nor collected and examined. It was assumed to be a real thing that escaped from the soil at night, for venturing abroad at night was the common prelude to an attack. Therefore, prophylaxis included not only staying indoors after nightfall, but measures to exclude the mischievous miasm from the dwelling. This was partially effective prophylaxis, based not on actual knowledge, but on observation. Until the real cause of malarial fever was discovered to be infected Anopheles, it was not possible to apply the true prophylactic remedy of abolishing their breeding-places, as far as practicable, treating those which cannot be abolished so that the conditions are not favorable to breeding, destroying their larvæ, and protecting infected persons from being bitten by the uninfected insect host, which then could spread the infection. The old prophylaxis was good, as far as it went; the new could not have been instituted without knowledge of the real etiology.

Prophylaxis is connected to some extent also with the science of therapeutics. Thus, the prophylactic use of the curative quinin has long been known to be a valuable defense; and although the cause of diphtheria was understood some years before the discovery of the specific antitoxin, it was not until the value of this agent had been proved in the sick-room that its use as an immunizing agent was suggested and put in practice.

Prophylaxis is interwoven, also, in a large degree, with the science

of sociology. It is something more than the mere prevention of infection through municipal sanitation and national and state quarantine. It concerns itself with promoting normal, wholesome methods of living, both physical and moral, and with all measures that may in any way promote health and well-being.

In the broad sense, prophylaxis deals with both the intrinsic and the extrinsic factors of disease. The former belong more especially to the domain of individual hygiene, the latter to that of national, State, and municipal hygiene. In the narrow sense, prophylaxis is public hygiene, and deals with the so-called preventable infective diseases and those which may truly be called occupational diseases. It is not a field belonging exclusively to the medical profession; it requires the services of the engineer, the law-maker, the sociologist, and the educated class in general.

Prophylaxis of the infective diseases deals with both the individual and the community. It strives to protect the individual from invasion of his system by morbific agents, and in the event of failure, so far as he is concerned, seeks to prevent the spread of the disease from him to others, for each infected person must be regarded as a possible focus of direct or indirect infection of others. In the broad application of the principles of prophylaxis the exciting causes of disease are not of greater importance and interest than the predisposing causes, since the latter make possible the invasion of the system by the former. The predisposing cause acts by overcoming the natural barriers with which the system is by nature endowed; that is to say, it reduces resistance or promotes susceptibility. Sometimes the exciting cause of one disease may be the predisposing cause of another, and it is, therefore, not possible always to draw a sharp line between them; but the predisposing cause, whether or not it be also an exciting cause, acts in the manner above indicated.

In the prevention of epidemic infective diseases, single measures may be necessary. The most important is the exclusion of the exciting cause; as, for instance, in cholera, bubonic plague, yellow fever, etc. If the cause enter a community in a diseased body, the important measures are isolation and disinfection, and, in case of smallpox, the creation of a condition of artificial immunity through vaccination. By disinfection we destroy the exciting cause of certain diseases, such as Asiatic cholera and typhoid fever; but against certain others the process is unavailing, and it is necessary to destroy not only the exciting cause, but the disseminating agent; thus, mosquitos in yellow fever and malarial outbreaks. In the endeavor to prevent the endemic diseases we find, as a rule, greater difficulties. The exciting cause is common and wide-spread, and while we may know what places and what things are best avoided, we cannot be sure that others supposedly safe are not infected. We may endeavor to overcome the influence of local causes; we may aim to limit the spread from individuals by isolation and disinfection; we may improve general sanitation in all ways possible, and yet there may still be only partial

abatement of the outbreak. Obviously, under such circumstances, some one or another epidemiologic factor has escaped attention.

The prevention of infective diseases by the application of sanitary measures on a large scale, *i. e.*, the installation of pure water-supplies, the removal and disposal of sewage, the drainage of soils, the disinfection of houses, the enforcement of quarantine restrictions, compulsory vaccination, the restraint of prostitution—is the chief aim of State medicine, which, however, concerns itself with still other important measures to conserve the public health, such as supervision of the food-supply and of the conditions under which the various occupations are conducted.

Enactment and enforcement of sanitary laws are a very necessary part of prophylaxis, even though sanitary law attacks individual liberty. This it must do, since, in order to protect the community, it is necessary in some degree to encroach upon what may be regarded as individual rights. Thus, it assumes the power to quarantine the individual and his home, and to invade it for the purpose of subjecting it to disinfection, in order that others may not be seized with the same disease through infective matters that have escaped from the person who has made quarantine necessary. It protects the individual from injury that might come to him in his health through the misfortune of another, even as it protects his person and property from another's lawless acts. It protects him to a certain extent from his own carelessness or indifference, on the broad principle that his health and his life are of importance to the well-being of the community. But, on the other hand, the individual demands as a right that his health shall be protected as well as his person and property, and he recognizes the justice of the extension of the same protection to others from his own misfortunes or misdeeds.

GOVERNMENTAL PROPHYLAXIS

National Boards of Health.—It is a common and erroneous idea that the public health in most countries other than our own is under direct supervision of national boards of health, and that this country greatly needs such a controlling force. As a fact, most of the important countries of Europe have no general sanitary law administered by central authority, but their public health interests, nevertheless, are not allowed to suffer. Great Britain stands out conspicuously as a country with a very perfect sanitary organization under central control. The controlling body, known as the Local Government Board, consists of a president, who is appointed by the king, a secretary, and a parliamentary secretary, besides a number of others who, though members by reason of holding some other office, are consulted only on matters of grave importance. Among the matters committed directly to the Board are the following: Regulations concerning the prevention and suppression of epidemics; inspection of vaccination; sanitary regulation of new buildings; appointment of

public analysts and port sanitary authorities, and approval of appointment of certain medical officers of health and inspectors of nuisances; control of poor-law relief and of poor-law medical officers; examination and approval or veto of plans for water-supply, sewerage, drainage, disposal of garbage, public buildings of various kinds (hospitals, schools, jails, asylums, etc.), sanitary supervision of places of recreation, etc.; inspection of the sanitary condition of the various districts; and oversight of local authorities who are neglectful. Orders of the Board have in general the force of law.

In addition to the general authority, there are many local boards of health, one for each sanitary district, and these report annually to the Local Government Board. The sanitary districts are of two classes—urban and rural. Each urban district employs a medical officer of health, a sanitary architect and engineer, an inspector of nuisances, a secretary, and such subordinates as may be needed; and each rural district employs a medical officer of health, an inspector of nuisances, and such assistants as are needed. In some cases different districts employ the same medical officer of health, and again some districts are so large as to require subdivision and the employment of a corresponding number of medical officers of health. The duties and powers of these officials are very considerable. Thus, a medical officer of health must keep himself informed concerning any possible injury to the public health; inquire into the origin and spread of diseases and the possibility of removal of their causes; advise concerning all matters affecting the health of the district, and "any question relating to health involved in the framing and subsequent working of such by-laws and regulations as they may have power to make"; investigate all outbreaks of infective disease and advise concerning their control; direct or superintend the work of the inspector of nuisances, and, if necessary, intervene in case of nuisances injurious to health or of overcrowding in a house; have general supervision of meats, fish, fruit, and other perishable or diseased foods exposed for sale, and give thereto his personal attention if so directed or advised; inquire into the processes followed in offensive trades, and report on means for preventing nuisance or injury to health therefrom; report measures for improving the public health and concerning sickness and mortality; record all visits made and observations and instructions; report annually a summary of his acts for preventing the spread of disease, an account of the sanitary state of his district, and his doings with regard to offensive trades, dairies, cow-sheds, milk-shops, factories, and work-shops; and perform many other duties of an administrative or advisory nature.

The inspector of nuisances, or sanitary inspector, who in large part is under the control of the medical officer of health, is required to keep himself informed regarding nuisances which may require abatement; to visit the premises where nuisances are reported as existing; to report any noxious or offensive businesses, trades, or manufactories, and the breach of any by-laws or regulations applicable

thereto; to report any damage to waterworks, all wilful or negligent waste of water, and any fouling of water used for domestic purposes; from time to time to inspect shops where meats, poultry, fish, fruit, vegetables, grain, bread, flour, milk, and certain other foods are sold, and to cause any of the same as appear to be unfit for food to be seized and brought to the attention of a justice; to procure and submit to the public analyst samples of food, drink, or drugs suspected of being adulterated, and in case of proved adulteration to cause prosecution of the vendor; to notify the medical officer of health of the occurrence of contagious, infective, or epidemic disease, and to call to his attention any nuisance requiring his intervention; to coöperate under direction of the medical officer of health in preventing the spread of dangerous diseases; to superintend, when so directed, all work undertaken for the suppression or removal of nuisances; and to keep records and perform various other administrative duties.

The registrars of births and deaths can be required to make weekly returns to the sanitary authority, but in case of deaths from infective disease, immediate returns may be required. The medical officer of health is regularly informed, by the clerk of the Guardians, of all new cases of sickness among paupers in his district, and returns are made to him by the poor-law medical officers also of pauper sickness and deaths, and notification is given of the outbreak of infective disease.

Local boards of health are required to construct and maintain in good order all sewers, and they can compel individual house-owners to connect with the sewers, or, if the distance be too great, to drain into cess-pools constructed as they may direct. A local board is obliged also to provide for the disposal of sewage, and in the performance of that duty it is permitted to exercise a wide discretion, but it may create no nuisance. A local board has jurisdiction also in the matter of sweeping and cleaning streets and courts, abating nuisances which may arise from any cause, preventing the keeping of animals in such a way as to be an injury to public health, compelling the cleaning of dwelling-houses, requiring the removal of manure or other offensive matter, constructing necessary waterworks and providing for the maintenance of the same, fixing of water-rates, making regulations for basement dwellings and common lodging-houses, regulating offensive trades and the sale of meats and other foods, disinfecting houses and their contents, removing persons suffering from dangerous infectious disease, building pest-houses, maintaining mortuaries, caring for streets and public buildings, regulating slaughter-houses, and attending to many other matters connected with the public health.

The sanitary authority has power in the event of threatened invasion by epidemic disease to make regulations concerning the speedy burial of the dead and house-to-house visitation, and it may provide medical service and accommodation, and compel cleansing,

ventilation, and disinfection. Any regulations so made must be enforced by the local authorities.

In addition, for the preservation of the public health, other special laws concerning sanitary matters have been enacted. The enforcement of these is intrusted to the sanitary authority and to the local authorities within their own districts. They include a law for preventing the pollution of rivers; another regulating the sale of adulterated foods and drugs; another concerning the production, inspection, and sale of milk; another concerning the sanitation of factories and work-shops, in which are included bake-houses; and various others having to do mainly with nuisances and industries. There are also laws concerning vaccination, disposal of the dead, sanitation of ships and prisons, notification of infective diseases, etc.

London alone is not under the control of the Local Government Board; it has its own public health act, which is equally efficient and more comprehensive. The chief sanitary authority is the London County Council, which acts in conjunction to some extent with the Metropolitan Asylums Board, which latter authority has the chief control of asylums and hospitals for infective diseases. Like the rest of England, London is subdivided into a number of districts, each with its own local health authority; but that part of the metropolis which is known as the "city" has its own government, and is not directly under the supervision of the London County Council. Sanitary matters in the city are intrusted to a Commission of Sewers, which also acts as the Port Sanitary Authority for the Port of London.

From the above it may be seen that England is provided with a very comprehensive scheme of sanitary government, and that the matters within the control of the various authorities cover practically every branch of public hygiene.

Scotland has practically the same sanitary machinery and practically the same sanitary laws.

The Continental nations have no such sanitary organizations as obtain in England and Scotland, and yet they have an abundance of sanitary laws and an adequate force of officials for their enforcement. In France, the Minister of the Interior is the chief sanitary authority; second in rank comes the Comité Consultatif d'Hygiene Publique, which advises and reports on matters referred to it concerning vaccination, quarantine, epidemic diseases, general sanitary conditions, hygiene of occupation, and other topics; and in case a question is deemed of sufficient importance to be submitted to the National Academy of Medicine, it so advises. The committee, which is a large one, is made up of a number of government officials, who are members ex officio, and others, of whom about half are medical men, chosen, from lists submitted to him, by the Minister of the Interior. The committee is divided into special subcommittees, and it meets weekly. In case of emergency the Minister may call upon his Council, which consists of the president of the Comité Consultatif, the inspector-general of the sanitary services, the superintendent of

commerce, and the professor of hygiene of the Faculty of Medicine of Paris.

France is divided into districts, each of which has its council of public health, and if it is deemed necessary, additional committees are formed for the large towns. These local bodies have practically the same jurisdiction as the local boards of health in England. All questions concerning the prevention of epidemic and epizootic diseases, vaccination, sanitation of houses and localities, industrial hygiene, the hygiene of schools, asylums, hospitals, prisons, barracks, charitable institutions and other public buildings, the sale of adulterated foods, drinks, and drugs, the suppression of nuisances, the registration of vital statistics, etc., are referred to them by the prefect or subprefect of the district. Each district has, of course, a staff adequate for the performance of the duties with which it is intrusted.

There is, as has been mentioned above, another organization to which questions of importance are submitted by the Minister of the Interior on the advice of his consulting committee; this is the highest scientific authority in sanitary matters in France—the National Academy of Medicine. To it was intrusted, for example, a short time ago, the duty of considering the toxicity of the various liqueurs, with a request that two lists be made—one to include those dangerous to health and one those of harmless nature. The decision in such questions as are submitted to it is final.

Among special sanitary laws in France may be mentioned those concerning the sale of food and drink, unsanitary dwellings, the protection of children, the sanitation of dangerous trades, the employment of girls and children, the sale of poisons and medicines, the disposal and removal of the dead, the pollution of streams, and many other matters.

As with the largest city of Great Britain, so also with that of France, Paris has a sanitary organization differing in some respects from that of other departments. The authorities consist of the Prefect of Police and the Council of Public Hygiene and Salubrity of the Department of the Seine. In addition, the city is divided into different departments, each of which has its own commission, which is like those of the districts in other parts of the country.

In Germany, while there exists an Imperial Board of Health, the separate constituent parts of the Empire make their own sanitary laws, which, however, may not conflict in their essence with the general laws. The highest sanitary authority is the Chancellor of the Empire, and he has the assistance of the Imperial Board of Health (Reichsgesundheitsamte), which concerns itself with scientific problems, prepares laws and regulations, and collects vital statistics and other information of value in sanitation. Each component part of the Empire has, as has been said, its own sanitary machinery, but sanitary administration does not differ in important respects in the different governments. In Prussia, which may be taken as the type,

there is one sanitary authority to whom the officials of each province are responsible. Each province is divided into districts, each having its chief and council and a staff for the various subdivisions of sanitary administration, which are about the same as in all other countries. As in England and France, the chief city has its own sanitary government. Berlin is divided into districts, each with its own sanitary machinery, all responsible, however, to one chief.

In the United States the nearest approach to a national board of health is the United States Public Health and Marine-Hospital Service, created by Act of Congress, approved July 1, 1902, to take the place and perform the duties of the United States Marine-Hospital Service. Its duties are to care for sick and disabled sailors; to gather information concerning epidemic infectious diseases, not alone within the country, but beyond its borders; to examine embarking emigrants in foreign ports to determine their fitness for entry into the United States, its dependencies and possessions; to have the general oversight of quarantine laws and regulations; and to perform such other duties as may be delegated to it. For the proper performance of its duties it had, on July 1, 1910, a commissioned corps which included a surgeon-general, 6 assistant surgeon-generals, 36 surgeons, 70 passed assistant surgeons, and 21 assistant surgeons, and employed in addition 1 sanitary inspector, 274 acting assistant surgeons, some of whom were on duty at fruit ports in Central America and South America and at Bombay, Rio Janeiro, Guayaquil, Naples, Kobé, and Hongkong, several female medical inspectors, 15 internes, 46 pharmacists, 737 hospital attendants, 17 pilots, 20 marine engineers, and a staff of scientists connected with the Laboratory of Hygiene at Washington.

In caring for sick and disabled sailors it maintains 21 hospitals and 118 other relief stations, and operates a sanatorium for consumptives at Fort Stanton, New Mexico. In the administration of national quarantine it maintains 70 quarantine stations, where ships are inspected and, if necessary, detained and disinfected, and exercises quarantine supervision over outgoing vessels bound for the United States from Cuban ports and from fruit ports of Central America and South America.

The information which it gathers concerning the prevalence of Asiatic cholera, yellow fever, bubonic plague, small-pox, and cerebrospinal meningitis, whether in foreign countries or in the United States, its dependencies and possessions, is published weekly in reports which include also the public health and mortality statistics of the United States. The Hygienic Laboratory investigates public health problems from the standpoints of pathology, bacteriology, zoölogy, pharmacology, and chemistry; instructs officials in the service, especially in the field of combating epidemic diseases; examines antitoxins, serums, viruses, and drugs; makes and distributes the American unit by which the strength of diphtheria antitoxin is standardized; investigates the germicidal value of disinfectants; and con-

ducts a wide variety of scientific investigations concerning the etiology and suppression of epidemic and epizootic disease.

Such a national board of health as the Local Government Board of England is, under the Constitution, not possible in this country, since local sanitary administration is a matter which belongs to the individual sovereign States. Congress can legislate for the District of Columbia, and can pass certain general health laws which may be necessary for the public safety, but it cannot prevent the individual States from adding as much as they may choose to national restrictions. Thus, a State must conform to the minimum requirements of the national quarantine law, but it can add what it may deem necessary for the safety and happiness of those within its own borders. Congress can, if it so chooses, under its right to regulate interstate commerce, pass a general law concerning the adulteration of foods, but such could not apply to foods not subject to a special revenue tax, which are produced, adulterated, and sold within the borders of any one State, though it could apply to those shipped beyond said borders. Similarly, it can, as it has done, pass a law to regulate interstate commerce in vaccines and antitoxins, but it cannot supervise or restrict the manufacture and distribution of these articles if they are not to go outside the State. For example, the State Board of Health of Massachusetts produces and distributes throughout the State vaccine virus and diphtheria antitoxin, and since these are not offered for sale to the people of other States, the national authorities have not the right to enter the premises where they are produced nor to require that they shall conform to any standard; but the plants of those whose products are sent broadcast are subject to inspection, and the products must conform to established standards. To pass general laws concerning the protection of water-supplies, the control of dairies, the disposal of sewage and garbage, the notification of infective diseases, the sanitation of dwellings and public buildings, the control of nuisances, the employment of women and children, and other matters of local interest and importance is not within the province of the national government, but belongs to the individual States. How far each State may choose to go in the enactment of laws for the protection of the health of its inhabitants is a matter which is for itself to decide.

State Boards of Health.—Each State in the Union has enacted laws concerning the public health; and for their proper administration and enforcement State Boards of Health or equivalent commissions have been established. In those States which are foremost in sanitation the Board of Health or Health Commissioner is the analogue of the Local Government Board of England. The duties intrusted to it (or him) are wide, and its powers are correspondingly large. As a fair example of these powers and duties may be cited those of the State Board of Health of Massachusetts, which "shall take cognizance of the interests of health and life among the citizens of the commonwealth, make sanitary investigations and inquiries

relative to the causes of disease, and especially of epidemics, the sources of mortality and the effects of localities, employments, conditions, and circumstances on the public health, and relative to the sale of drugs and food and the adulterations thereof; and shall gather such information relative thereto as it considers proper for diffusion among the people. It shall advise the government relative to the location and other sanitary conditions of any public institutions; and shall have oversight of inland waters, sources of water-supply and vaccine institutions, and may, for the use of the people of the commonwealth, produce and distribute antitoxin and vaccine lymph. It shall annually examine all main outlets of sewers and drainage of cities and towns of the Commonwealth and the effect of sewage disposal, and shall annually report thereon to the general court, with such recommendations for the protection of the interests of persons and property and for the prevention of offensive odors and objectionable conditions as it considers expedient." Additional powers and duties were conferred and imposed by a special act in 1902, which abolished the office of inspector and assayer of liquors and transferred the powers and duties of that official to the Board.

The Board consists of seven members, who receive no compensation whatever and who are appointed by the Governor, with the advice and consent of the Council, for a term of seven years. One member is named annually. It holds its meetings at least once in each month, and special meetings according to need therefor. The executive officer of the Board is the Secretary, who is appointed by the Board and holds his office during its pleasure. For the performance of its varied duties it employs an adequate staff of engineers, chemists, pathologists, bacteriologists, assistants, draftsmen, clerks, and stenographers; maintains laboratories; and is provided with a proper annual appropriation for necessary expenses. It has coordinate powers with all local boards, and in the event of neglect on their part to act in the interest of the public health, may intervene.

In the performance of its duties relative to the sale of drugs and food it employs inspectors and chemists, and maintains a laboratory which is thoroughly equipped with the most modern appliances and apparatus. The inspectors collect samples throughout the State and deliver them to the chemists, who report directly to the Secretary, who, in his discretion, directs the inspectors to enter and conduct prosecutions in the various courts of first resort. In case it seems desirable and proper, warning notices are sent by direction of the Secretary to the vendors. Each year many thousands of samples of foods and drugs are examined, and each month a bulletin is issued containing information concerning the work of the Board in this field, with the names of all persons prosecuted, the nature of the offenses, and the names of all brands of foods and drugs found to have failed to conform to the requirements of the statutes. Foods produced under unsanitary conditions, especially milk from dirty dairies, where infective diseases may not necessarily exist, are a very important

factor in disease. The meat of diseased animals; meat-products subjected to unwholesome influences which beget toxic substances; meats, fish, ales, beers, jams, jellies, milk, butter, cheese, canned fruits and other vegetable products, sausages, oysters, clams, and other foods containing chemical preservatives or substances universally acknowledged to be directly poisonous, such, for instance, as wood alcohol (flavoring extracts) and arsenic (beers made with impure invert-sugar and glucose), all demand attention on the part of public authorities.

For the performance of its duties relative to the purity of inland waters and the supervision of public water-supplies the Board employs a staff of engineers, draftsmen, and chemists, and maintains proper accommodations for each class. It has "the general oversight and care of all inland waters and of all streams and ponds used by any city, town, or public institution, or by any water or ice company . . . . as sources of water-supply, and of all springs, streams, and water courses tributary thereto." It "may cause examinations of such waters to be made to ascertain their purity and fitness for domestic use or their liability to impair the interests of the public or of persons lawfully using them, or to imperil the public health. It may make rules and regulations to prevent the pollution and to secure the sanitary protection of all such waters as are used as sources of water-supply." It is required to make an annual report of its doings, to "recommend measures for the prevention of the pollution of such waters and for the removal of polluting substances, in order to protect and develop the rights and property of the Commonwealth therein, and to protect the public health, and recommend any legislation or plans for systems of main sewers necessary for the preservation of the public health and for the purification and prevention of pollution of the ponds, streams, and inland waters of the Commonwealth." It consults with and advises "the authorities of cities and towns and persons having, or about to have, systems of water-supply drainage, or sewerage, as to the best method of disposing of their drainage or sewage with reference to the existing and future needs of other cities, towns, or persons which may be affected thereby." It consults with and advises "persons engaged or intending to engage in any manufacturing or other business, whose drainage or sewage may tend to pollute any inland water, as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of drainage or sewage." These consultations, advice, and experiments are given and made free of all expense to those requiring them. All proposed systems of water-supply, drainage, and sewerage must be submitted to the Board, and its recommendations and advice must accompany all petitions to the General Court for authority to introduce any such system. Upon complaint that the waters of any stream, pond, spring, or water-course used by any city, town, institution, or water or ice company, as a source of water-supply, are exposed to the danger of pollution

from sewage matters, the Board must appoint a time for a hearing and serve notice thereof to interested parties; and on the evidence given it may, if it deems it necessary for the protection of the public health, make such orders as may be required for protection against the polluting influence; and whoever violates any regulation or order so made is subject to a heavy fine and term of imprisonment. Thus, not only has the Board an advisory function, but it may make rules and regulations that have the force of law. The State not only protects water-supplies from pollution, but by special enactment requires all manufacturing establishments, whether supplied by public waterworks or not, to "provide fresh and pure drinking-water, to which their employees shall have access during working hours." The Board is empowered also to make such orders relative to the sale of ice as in its judgment the public health requires, provided that not less than 25 consumers of an ice supply complain in writing that the ice is impure and injurious to health.

In addition to making annual examinations of all sewer outlets of cities and towns, and giving advice concerning the disposal of sewage, the Board may approve of the taking or purchase of land by cities and towns for the purification and disposal of sewage, and for the protection of the public health from the spread of infective disease through sewage-polluted shell-fish; it may determine the bounds of contamination of tidal waters and flats by sewage, and may cause the taking of oysters, clams, quahaugs, and scallops therefrom to be prohibited during such time as it may prescribe.

For the proper performance of its duties relative to the production and distribution of diphtheria antitoxin and vaccine lymph the Board maintains a model plant and laboratory, the products of which are subjected to careful test and examination before they are distributed to local boards of health and public institutions. No charge whatever is made to those who need them, and large quantities of the antitoxin are sent to public institutions for use, not alone in the treatment of the disease, but for conferring immunity upon the inmates—a real prophylactic measure of the greatest value. It distributes also throughout the State culture outfits for diagnosis of diphtheria and boxes for the collection of sputum, examines them after use, and makes immediate returns by telegraph, telephone, and mail. It also applies the Widal test for typhoid fever, and makes blood examinations for the malarial parasite for any citizen within the Commonwealth. For none of these examinations is any charge made.

Under the general law requiring it to make sanitary investigations and inquiries relative to the causes of disease and to gather information relative to public health matters the Board can, of course, exercise a very wide discretion in its choice of work not definitely provided for by the legislature. Although it is not charged with the duty of recording vital statistics, it receives immediate returns of cases of communicable diseases from the local boards and annual returns of

deaths from all causes from communities with populations in excess of 5000.

The public health law of the State of New York confers upon the Commissioner of Health, who is the sole member of the State Department of Health, very extensive authority, and imposes upon him a corresponding degree of responsibility in conserving the public health and abating nuisances. He is empowered to designate one of his assistants who shall possess his powers and perform his duties during his absence or inability to act. The law requires him to take cognizance of the interests of health and life of the people and of all matters pertaining thereto; to make inquiries regarding the cause of disease, especially of epidemics, and to investigate the source of mortality and the effect of localities, employments, and other conditions upon the public health. He is charged with the conduct of the Bureau of Vital Statistics for the registration of births, marriages, deaths, and prevalent diseases throughout the State; to prescribe and prepare methods, forms, and rules regulating the issue of transfer permits by local boards of health for the transportation of corpses; to make examination into nuisances or questions affecting the security of life and health in any locality; and to exercise the powers of a local board of health and appoint a health officer thereof in any town which, being authorized by law to establish a local board of health, fails to do so.

In the performance of his duties the Commissioner has many of the powers of a magistrate or court of record, being authorized to issue subpœnas and to compel witnesses to testify in any matter or proceeding before him. He has power to reverse or modify an order, regulation, by-law, or ordinance of a local board of health concerning any matter affecting the public health beyond the territory over which such board has jurisdiction; to exercise exclusive jurisdiction over all lands acquired by the State for sanitary purposes; to authorize any person to enter, examine, and survey all grounds, vehicles, buildings, and parts of buildings; to examine into the enforcement of laws relating to tenement houses in any city of the first class; to make the necessary inquiries and investigations relating to the sale and adulteration of food, and to adopt measures to make such regulations in addition to the statute provisions as may seem necessary for their enforcement; to make rules and regulations for the protection of public water-supplies, and their sources within the State, from contamination; to make orders or regulations concerning the construction and maintenance of any system of sewerage or any change thereof in or for any village or hamlet.

In the examination of any nuisances for the purpose of determining whether a public nuisance exists, the Commissioner may call upon any city board of health to appoint one of its members to act with and assist him, but the final determination of the questions involved rests solely with the Commissioner.

In the State of Pennsylvania the State Department of Health

consists of a Commissioner of Health and an advisory board of six, a majority of whom are physicians of at least ten years' experience. One member of the advisory board must be a civil engineer. The advisory board is required to give advice to the Commissioner on such matters as he may bring before them, and to draw up orders and regulations which they may deem necessary for the prevention of disease and for the protection of the lives and health of the people, and for the proper performance of other work of the department. In addition, the Commissioner may employ competent persons to make investigations and examinations requiring expert skill; he may issue subpœnas to secure the attendance of witnesses and compel them to testify before him, or his authorized agent, in any matter or proceeding; and he may issue warrants for the arrest of such persons who disobey quarantine orders or regulations of the department. It is his duty to protect the health of the people, and to determine and employ the most efficient means for preventing and suppressing disease; to cause examinations to be made of nuisances or questions affecting the security of life or health in any locality; to order nuisances to be abated or removed; and to enforce quarantine regulations. He is given general supervision of State registration of vital statistics, of practitioners of medicine and surgery, of mid-wives, nurses, and undertakers, and of all persons whose occupation is deemed to be of importance in obtaining complete registration of births, deaths, marriages, and disease, and to prescribe and prepare necessary methods and forms for obtaining and preserving such statistics.

Chapter 182 of the Acts of 1905 provides that all municipal corporations, private corporations, and others supplying water to the public shall file with the Commissioner of Health certified copies of plans and surveys of waterworks, with a description of the source from which the supplies are derived, and that no additional sources of supply shall be used without a written permit from the Commissioner of Health. The application for such a permit must be accompanied by certified copies of the plans and surveys for such waterworks or extension thereof. It provides, further, for the general supervision of systems of sewerage within the State.

It is not intended to imply that all or nearly all State boards of health have equal powers and equipment for doing public service, nor is it meant to assert that other boards may not have greater authority and larger appropriations. The instances given illustrate what a central sanitary authority may have to do, and the machinery employed in the performance of its various duties. In some States the authority of the Board is far less extensive; and in many the annual appropriations are too small to permit of effective service.

Municipal Boards of Health.—It is a matter much to be deplored that in this country the political organization and customs are such that efficient local sanitary administration is far from being the rule. In many cities where the office of Health Commissioner carries with it a respectable salary, tenure of office is dependent not so much upon

fitness and efficiency as upon favor. Like other salaried positions, the office is looked upon as a part of the legitimate spoils of a political campaign; and where the view obtains with respect to those in charge of local sanitation, it obtains with equal force with respect to subordinate positions. In small cities and towns which do not pay the members of the board of health anything more than a nominal salary, efficiency may or may not be expected according to circumstances. The assured tenure of office is short in any event; energetic enforcement of regulations relating to nuisances may disturb and conflict with the interests of influential politicians; or they may involve the expenditure of moneys not available; or they may cause unfriendly feelings on the part of neighbors.

The member of a local board of health is beset by A and his friends to declare the premises of B, which are dirty and wet, to be a menace to health and a public nuisance; and B and his friends reciprocate by asserting that A's stable is a danger and ought to be cleaned and disinfected or torn down; C regards as unreasonable an order to make connection with a public sewer, on account of the attendant expense, while D insists that C's cess-pool is an offense to the neighborhood; E complains that quarantining his house merely on account of the presence of a case or two of scarlet fever is a hardship and an outrage, as well as a violation of the Bills of Rights, and F is sure that the milk of G's cows cannot be proper for sale and consumption, because the water in the pasture is covered with green slime; H complains that the board is unfit for office because it will not, in violation of his rights, compel J to stop practising the cornet in the early morning, and K regards it as ignorant of the first principles of sanitary science when it cannot agree with him that the presence of a dead hen in L's yard may cause an outbreak of malaria and typhoid fever. Receiving no salary for gaining the ill will of his neighbors, and feeling that no special obligation to neglect his business in order to perform his thankless tasks, or not wishing to offend the local political power and his friends whose votes may be needed by himself or a relative or a friend in the next campaign, it is not to be wondered at that, outside of routine duties imposed by statute, it so commonly happens that the local authority does little for local sanitation.

Of course, cities and towns differ much in the matter of sanitary administration. One which pays no salary may be fortunate in public-spirited citizens who will give efficient service fearlessly and constantly, while the adjoining town, which pays its board a nominal sum, is the prey of politicians, to whom the small amount of patronage, the opportunities for "commissions," and the exercise of power constitute a valuable asset.

In this country local boards of health are clothed with very great authority within the limits of their own territories, since they can add to the restrictions imposed as a minimum by the central authority or by the general statute. Thus, the legislature may pass laws against the sale of adulterated milk, and the local board, having ruled that

dirty milk is a source of disease, can go still farther and prohibit the sale of that which contains more than a specified number of bacteria in a given volume. A legislature may make it necessary that a man secure a license before engaging in the sale of milk, and the local board can compel him to store his milk in a particular manner, to maintain it at a temperature not in excess of 50° F., to have means at hand for sterilizing all cans and other receptacles, and to conform to many other established requirements. A legislature may make laws requiring notice to the local board of the occurrence of communicable diseases, and the local board may prescribe the manner and extent of house quarantine and the method to be followed in the subsequent disinfection.

Among the prophylactic measures which come within the province of the authorities of cities and towns may be mentioned the following: The establishment of hospitals for the treatment of communicable diseases and of isolation hospitals for the reception of persons having small-pox or other dangerous and undoubtedly contagious disease; the placarding of houses where communicable diseases exist; the forcible removal of persons suffering with dangerous diseases to appropriate places for treatment; disinfection of houses and their contents; notification to school committees, as well as to the State Board of Health, of the existence of all cases of contagious diseases; supervision of boarding-places for infants; examination into, and the destruction, removal, or prevention of, all nuisances and causes of sickness; establishing and enforcing regulations for the public health and safety relative to house drainage and its connection with public sewers, and to the construction of privy vaults and cess-pools; condemnation of unfit dwellings and prescription of necessary repairs and alterations; assignment of places wherein offensive and dangerous trades and occupations may be carried on, and revocation of permits to carry on the same; establishment of quarantine grounds; enforcement, if it be deemed necessary, of vaccination and revaccination of the entire population, with the exception of those legally exempted therefrom; regulation of cemeteries and interments; licensing of undertakers; regulation of the disposal of garbage and other filth; supervision of plumbers and plumbing; collection of vital statistics; inspection of milk, meats, and other foods, and of animals intended for slaughter; and the medical inspection of schools. The above are the matters which are committed to local boards of health by the laws of Massachusetts, with the exception of the last mentioned, which duty is assumed by certain boards under the general provisions for protecting the public health. In a number of the cities of Massachusetts municipal bacteriologic laboratories are maintained for the examination of throat cultures for the diagnosis of diphtheria, of sputum for the diagnosis of tuberculosis, and of blood for the diagnosis of typhoid fever and malaria.

Chapter 466 of the laws of 1901, being the Greater New York Charter, provides that the Board of Health shall enforce all statutes

relative to the preservation of human life or to the care, promotion or protection of health, including all laws relative to cleanliness or to the use or sale of all poisonous, unwholesome, deleterious drugs, medicines or foods, and the necessary sanitary supervision of the purity and wholesomeness of the water-supply and the sources thereof, for the city of New York. It is "authorized to require reports and information at such times and of such facts and generally of such nature and extent relative to the safety of life and promotion of health as its by-laws or rules may provide, from all public dispensaries, hospitals, asylums, infirmaries, prisons, and schools"; and from all other public institutions, and all theaters and other places of public resort or amusement; "but such reports and information shall be required only concerning matters or particulars in respect of which it may, in its opinion, need information for the better discharge of its duties." The Board is charged to use all reasonable means for ascertaining the existence and cause of disease or danger to life or health and for averting the same, and to gather and preserve such information and facts relating to death, disease, and health from other parts of the State, but especially in the city, as may be useful in the discharge of its duties and to contribute to the promotion of health or the security of life in the State. It is charged to give all information that may be reasonably requested concerning any threatened danger to public health to the health officer of the port of New York and to the commissioners of quarantine, who shall give like information to the Board, and the Board and the health officer of the port and the quarantine commissioners are required to coöperate to prevent the spread of disease and for the protection of life and the promotion of health within the sphere of their respective duties.

The Board has the power of summary removal of persons sick with contagious diseases, has exclusive control of hospitals for the treatment of such cases, and has the right to establish isolation hospitals which shall be under its exclusive charge. It may take possession of and occupy any building or buildings as temporary hospitals during the prevalence of an epidemic, and may cause sick persons to be taken thereto or to any place that it may indicate.

It has power to order and enforce repairs of buildings, houses, and other structures, to regulate and control the public markets so far as relates to cleanliness, ventilation, drainage, and the prevention of sale of improper articles; to cause the removal of any obstruction in or upon the streets, sidewalks, or places, and the prevention of accidents by which life or health may be endangered, and, generally, to abate all nuisances. It may establish, within its discretion, reasonable regulations as to the disposition of any of the papers, files, reports, records, and proceedings of the department, and may publish such information concerning births, deaths, marriages, sickness, and the general sanitary conditions of the city or any matter, place, or thing therein that, in its opinion, may be useful.

In case of impending danger of epidemic disease, the Board is

required to take such measures and do and cause to be done such acts and make such expenditures beyond those duly estimated for or provided as it may deem to be necessary for the preservation of the public health, but with the written approval of the mayor.

In the department are included two bureaus, the chief officer of one being known as "sanitary superintendent," and of the other, the "registrar of records." The Board is provided with branch offices in each and every borough, each being provided with a sufficient corps of officers, agents, and employees, including assistant sanitary superintendents, assistant registrars of records, and other officers, clerks, inspectors, and subordinates. In the exercise of its duties in the prevention of danger from contagious or infectious diseases or for the care of persons exposed to danger from contagious or infectious diseases, the department is empowered to expend in compensation of special inspectors, physicians, and nurses, and for supplies and contingencies, a sum not exceeding $80,000 in excess of its annual appropriation.

The local boards of health of the State of New York are required to make public such orders and regulations as they may deem necessary and proper for the preservation of life and health, and to execute and enforce the public health law and to suppress nuisances. A local board may issue subpœnas compelling the attendance of witnesses, and require them to testify under oath, and for such purposes it has the same powers as a justice of the peace; but such subpœnas may not be served outside of the jurisdiction of the Board, and no witnesses shall be compelled to testify in relation to matters not connected with public health; it may issue warrants to any constable or policeman of the municipality to arrest and remove such persons as cannot otherwise be subjected to its orders or regulations; it may issue a warrant to the sheriff of the county to bring to it aid should occasion require the powers of the county; and it has authority to direct the board of trustees in any incorporated village properly and safely to sewer such village. Every such board is required to supervise and make complete registration of vital statistics according to methods and forms prescribed by the State Department of Health; to prescribe sanitary regulations for the burial and removal of corpses; to guard against the introduction of contagious and infectious diseases by proper and vigilant inspection and control of all persons and things arriving in the municipality from infected places; to require the isolation of all persons and things infected with or exposed to such diseases; to provide suitable places for the treatment and care of the sick who otherwise cannot be provided for; to prohibit and prevent all intercourse and communication with, or use of, infected premises, places, and things; to require and, if necessary, provide the means of thorough purification and cleansing of the same before general intercourse with the same, or use thereof, shall be allowed; to report to the State Department of Health, without delay, facts relating to contagious and infectious disease, and every case of small-pox within

the municipality; to receive and examine into all complaints concerning nuisances or causes of danger or injury to life and health; to enter any place or premises where such are known or believed to exist; and to inspect and examine the same; and to order the suppression or removal of all nuisances and of conditions detrimental to life and health.

For the country at large it is doubtless the fact, as asserted in American Medicine of June 10, 1905, that "in a majority of cities having notification ordinances there are no isolation hospitals, no disinfecting stations, no adequate provision for house disinfection, although the Board of Health may be fairly well manned with illiterate disinfectors and inspectors of nuisances." Moreover, "in all sorts of notification required by law physicians are more or less indifferent and exercise a discretion that is somewhat excessive and dangerous, even for men as wise and good as the best of them are." It is a fact much to be regretted that, as stated by the same writer, the registration of vital statistics is required in but 10 of the States; for registration of vital statistics is a most important branch of prophylaxis, since it is only by such means that the value of sanitary measures and the injurious effects of their neglect can be measured.

INDIVIDUAL PROPHYLAXIS

The aim of the study of individual prophylaxis is the promotion of the health and well-being of the individual, rather than of the race or community, so that he may be brought into the best condition of resistance to disease processes; and herein enters the consideration of individual peculiarities and predispositions. One must seek to bring about and maintain a condition of equilibrium between the functional demands of the system and the power of the system to meet them, for in such a condition the body is enabled to adapt itself to sudden changes involving increased functional activity, acting automatically like a piece of delicate mechanism. Thus, the skin acts in one way to conserve the body heat and in another to lose it; the muscles and the circulatory apparatus respond to increased demands for physical effort, and the broken-down cells and tissues are replaced through normal processes of repair, while the effete matters are eliminated through the appropriate channels. In the condition of normal equilibrium the invading exciting causes of disease meet the natural defenses of the system and fail to establish a foothold; they are opposed by various bactericidal agents and destroyed, or they find themselves confronted by barriers which they cannot pass. A disturbance of this equilibrium, on the other hand, brings about a diminution of resistance and invites pathologic processes; for in this depressed state, what before might have been met by an automatic adjustment to temporary conditions, may cause functional disturbance and an altered state of particular tissues. Thus, one may have in the mouth cavity or in the intestinal tract various forms of pathogenic

organisms day after day and enjoy perfect health, because of the power of the tissues to resist invasion, but through exposure to cold, or through deprivation of food, or through great fatigue or dietetic indiscretion, the normal defenses are weakened and the hitherto harmless bacteria exhibit their characteristic, dangerous functions. Under these circumstances the pneumococci so often found in normal mouths may excite pneumonia; the streptococci, endocarditis; the common colon bacillus, inflammatory conditions of the peritoneum and so on.

It is not to be supposed that a condition of apparently perfect health confers immunity to all seemingly simple and unimportant external stimuli. An athlete in perfect physical condition may indiscreetly expose himself after violent exercise to some depressing influence, and shortly afterward, in consequence thereof, he may have the high temperature and sense of general weakness that accompany an attack of tonsillitis; while his more cautious but far less strong and healthy companion in exercise has not let down his barriers and continues to keep in condition. Today, one's tissues appear to be capable of overcoming a large number of streptococci introduced into a punctured wound; tomorrow, from one or another cause, the resistance is low, and a slight abrasion on the foot may admit the agents of a general septicemia.

The maintenance of a condition of health is far from being wholly dependent upon the grade of constitution with which one happens to be endowed. The inherited peculiarities which help to make what we term a strong constitution may protect the individual from attacks of certain forms of disease, but not from others. While he may resist invasion by certain species of pathogenic organisms, to others he may be an easy prey; and as to those pathologic processes of unknown etiology, he may be no more immune than another of weak constitution. Long family history of freedom from tuberculous taint is no guarantee of immunity from the exanthematous diseases or typhoid fever or liver cirrhosis. Nor is the individual who is not blessed with a strong constitution necessarily prone to sickness, especially if he leads a normal life and avoids the exposures, indiscretions, and excesses which tend to depress his physiologic resistance. A strong constitution may be weakened and a weak one strengthened by acquired peculiarities and the ever-changing conditions of life.

Since in individual prophylaxis one has to deal with individual conditions, peculiarities, and predispositions, it must be obvious that no general rules can be drawn to suit all alike. In the matter of age alone, for example, we have to consider that conditions change, for the prophylaxis adapted to infancy and childhood must differ in many essentials from that demanded by the conditions of old age, when certain supportive measures are indicated which, in the early age periods, would be wholly contraindicated. In the matter of sex, too, important differences in prophylaxis must obtain. And in the case of individuals of the same age and sex it must be obvious that personal

peculiarities constitute most important factors in resistance to disease. One may have an inherited predisposition to tuberculosis and an acquired immunity to small-pox and scarlet fever, while another has neither a tuberculous taint nor acquired immunity to those diseases from which the former has recovered. This person requires much sleep; that finds his bed irksome after seven hours. What is recreation to one is drudgery to another; this one finds that the maintenance of a healthy state requires an amount of outdoor exercise which would produce only fatigue in another; and in the matter of diet it truly has been said that one man's meat is another man's poison. It is no more possible to lay down general rules as to work and rest, diet, and the use of stimulants than to prescribe one's line of reading, or amusements, or choice of occupation; but it is possible to advise the individual according to his own peculiarities how best to live, counseling moderation in all matters instead of excess, and the avoidance of contact with infection, and of all conditions and circumstances which are known to predispose to disease.

Of very great importance in individual prophylaxis is the choice of occupation, since many callings are most unsuited to those with hereditary predispositions. For example, a person with a long family history of tuberculosis should choose an outdoor occupation rather than one which involves confinement, and especially confinement in dusty atmospheres. Here we have to consider the influence of harmful external causes, which is a very different matter from removing exciting causes of disease and offering opposing influences. Occupational prophylaxis is very largely a matter of governmental concern. Many foreign countries and several of the States of the Union have enacted factory laws which stipulate the conditions under which women and children may be employed and under which the occupations classed as dangerous to health or limb shall be conducted. While the subject is one of the most important of those to be taken into consideration in individual prophylaxis, adequate discussion of the essential features would require far more than the space available, dealing, as would be necessary, with many different classes of occupations, each having its own objectionable features: thus, those in which overcrowding and consequent vitiation of the air are fairly constant concomitants; those which involve exposure to extremes of heat, to abnormal atmospheric pressure, to dampness, to irritating and poisonous gases and dusts, to infective matter, to offensive gases and vapors; and those involving constrained attitude, sedentary life, overexercise of separate groups of muscles, and exposure to stress of weather.

As with occupation, so with diet, work, and exercise, the use of alcohol and tobacco, the choice of climate, etc., each individual's peculiarities have to be considered.

PROPHYLAXIS OF INFECTIOUS DISEASES

One of the most important branches of prophylaxis is the proper care of the patient, from whose system the exciting cause of an infective disease can be disseminated in one or another manner. Hence in those diseases, especially, in which infection by direct contact is a possibility, and in other diseases in which the spread by direct contact is improbable, yet possible, isolation of the patient is a valuable measure of defense. Having isolated the patient in a proper and thorough manner, we have then to prevent, in every way possible, the dissemination of material containing the exciting cause of his disease, and so far as we can to destroy it.

Isolation means something more than restraining the patient, although this seems to be the meaning of the term in the minds of many persons, who consider that when a patient is confined to a room in a remote part of a house, he is sufficiently isolated, and that there he may receive visitors, as many as may be admitted to see him. The folly of such an opinion needs no discussion. Many persons appear to believe that confinement in an upper story confers absolute immunity to disease on other persons in the same house, regardless of the fact that the door of the sick-room may stand open the entire day. The possibility of dissemination of infective matter by moving air seems often not to be thought of, especially from one story to another. It would seem almost as though it were the belief with some persons that infective matter is not subject to the law of gravitation, but has a tendency to rise. It seems to be also a common idea that although the air of the sick-room may be charged to some extent with disease germs, the air of the hall or adjoining rooms cannot be infected, even though the doors stand wide open. While the aërial transmission of morbific agents is probably of less importance than that by objects and persons who have been in immediate contact with the patient, it must nevertheless receive consideration.

Under ordinary conditions it is not possible to prevent a certain degree of intermixture between the air of the sick-room and that of the house in general, but this can be to some extent accomplished, and the effort should be made not so much on account of the air itself as because of that which the air carries. In so far as we know, the exciting factors of contagious diseases are particulate, and when thrown off from the body follow, therefore, the ordinary laws governing dust particles. Hence an effort should be directed toward preventing to as great an extent as possible the escape of floating particles from the sick-room by hanging over the door leading to and from it (only one door should be accessible) a sheet kept moist with a disinfecting solution, such as 3 per cent. solution of carbolic acid or a solution of chlorid of lime of the strength of about a teacupful of the lime to about a gallon of water. As the door is opened some of the escaping dust and infective particles impinge upon the wet sheet and stick there, soon to be either killed, or lessened in their activity by the solution with which

they are in contact. The sheet must be kept moist or it is of no value as a screen, and should be changed from time to time.

It is because of imperfect understanding concerning the scope of isolation and the methods of dissemination of infective material that much of what passes for isolation is really worse than useless, because apparent, but unreal, protection is a greater menace than danger which is not at all concealed. In ideal isolation the patient should be so shut off from the rest of the house that the air from his room cannot mingle with the air of the other parts. This is sometimes, but not generally, possible. One may, perhaps, by means of a temporary partition, shut off a portion of an upper story or of an L in such a way as to secure practically perfect isolation.

If a bath-room for the use of the nurse and for the treatment and disposal of the excreta of the patient and his food remainders can be included in the quarantine area, so much the better; and here, if possible, may be introduced a gas or kerosene stove, wherewith to boil water for purposes of disinfecting infected towels, napkins, bed-linen, body-linen, and other articles which otherwise must be transported to the kitchen or laundry.

The area shut off should be furnished as simply as possible. It should be free from heavy hangings, woolen carpets, stuffed furniture, and other objects upon which infective matter can be deposited, and which are cleaned with difficulty. It should be so furnished as to admit of easy and thorough cleaning, and the simpler the furnishings, the more easily the room is kept free from dust and infective matter.

As has been stated above, isolation implies more than confinement in a remote part of a dwelling. Isolation is defined as the "state of being isolated; alone," and hence a person who is isolated cannot receive visitors other than those who minister to his wants. The fewer the number of visitors, the less the opportunity for disseminating infected matter.

In the care of the room there is but little to be said. It should be kept clean, but not by ordinary sweeping or dusting. These processes must be absolutely prohibited, in favor of cleaning by means of moistened mops or cloths, and the more often this is done the less is the likelihood of an accumulation of infected dust in the room.

If the disease is one that will permit it, the room should be flooded with sunlight as much as possible. Naturally, the room should be thoroughly ventilated; and when conditions permit it, there can be no more efficient method than that of the wide-open window.

The practice of exposing strong-smelling chemical substances in shallow saucers for the purpose of purifying the air of the sick-room still obtains in many quarters, although the impossibility of producing sterility of the air by any such method has repeatedly been shown. A saucer of diluted carbolic acid, or of iodin solution, or of a weak chlorid of lime solution, can have no effect whatever in the sick-

room, beyond that of imparting an odor and creating a false sense of security.

In the sick-room occupied by a person with an infectious disease that can be spread through fomites, there should be provided a receptacle in which bed-linen, body-linen, towels, napkins, etc., may be deposited prior to disinfection by boiling water. Some prefer cotton bags, wet with corrosive sublimate solution (1 : 1000) or other strong germicide, such as carbolic acid and the cresols. These, when filled, can be deposited without further opening into the receptacle in which the boiling process is conducted. Some use ordinary clothes-baskets or boxes, but these involve the further handling of the infected articles and their own disinfection. Where circumstances permit, the body- and bed-clothing of such patients, together with all other washable articles used by him, should be immersed in a vessel containing a disinfecting solution immediately on their removal from the person or the bed. An ordinary wash-boiler half filled with a 3 per cent. solution of carbolic acid will serve the purpose. The articles should be immersed in this solution, the vessel covered and allowed to stand for two hours. Its contents may then safely be taken from the room.

In those diseases of which the exciting causes have been discovered, preventive measures are naturally far more possible than in those of unknown etiology, for if we do not know the nature of a germ nor its ways of becoming disseminated, we cannot be sure of the best method of preventing such dissemination. Thus, in measles and mumps we are beset by difficulties which do not obtain in dysentery, typhoid fever, and diphtheria. In diphtheria, for example, we know the exciting cause and where it is. We endeavor to prevent, as much as possible, its being thrown out into the atmosphere. Anything that is likely to become contaminated by particles of membranes containing the exciting cause can be plunged into an efficient disinfectant, or burned, or boiled. We can handle mumps and measles in the same way, but we do not know, nor can we find out at present, what the exciting cause is, nor how it goes from person to person.

Infective matter coming from the mouth and air-passages (diphtheria, whooping-cough, influenza, tuberculosis, lobar pneumonia), from the skin (the exanthemas), and from the bowels and the bladder (typhoid fever, dysentery, cholera), should be thoroughly disinfected and destroyed. Cloths used for receiving secretions from the mouth and nose should be disinfected and destroyed by burning.

Infective stools (dysentery, typhoid fever, tuberculosis of the intestines, Asiatic cholera) should be treated with efficient disinfectants so as to be made quite sterile. The urine in typhoid fever should be similarly treated. Concerning the best methods of treating these excreta, see under Disinfection (page 60).

All utensils used in feeding the patient may, in certain cases, need disinfectant treatment; and this is, as a rule, a very simple matter, since they can usually be placed in boiling water.

In diphtheria the somewhat profuse secretions from the nose and throat are likely to be sent forth to considerable distances from the patient through coughing, and also to escape on the pillow from the nose and mouth. Naturally, a small bit of membrane may contain countless bacilli, and since these bacilli, under favorable conditions, may preserve their virulence for some time, it is most advisable to prevent, as far as may be possible, their dissemination in the sick-room. In scarlet fever we have to deal with a disease of doubtful etiology, except in so far as Mallory's discovery of protozoal bodies in the skin may be accepted. It would appear, from long clinical observation, that whatever the exciting cause, it is resident not only in the epidermis, but in the secretions of the upper air-passages and of the ear. Consequently, these must all be regarded as worthy of the greatest care; and the more so since, as a rule, in this disease we have to deal with a mixed infection with streptococci of a very virulent type.

Of great importance is the avoidance of carriage of infection by the attending physician, nurse, and such members of the family as must be admitted to the sick-room. Although in some instances this danger may be exaggerated, it is better to err on the side of safety and to reduce the danger to a minimum. The attending physician and all other persons who can properly avoid doing so should refrain from bringing their persons in direct contact with anything which may have become, in one way or another, infected with material from the patient. It is necessary for the nurse, but not for the mother or other necessary visitor, to come in direct contact with the bed-clothes and the bed-pan. It may be necessary that the physician shall come in direct contact with the patient, but not that, having done so with his hands, he shall then proceed, before washing them, to run his fingers through his hair or to stroke his beard and mustache, or place his hands in his pockets, and then go hence to other patients, perhaps in the puerperal condition. Every person on leaving the infected area should at least wash his hands, and in visiting contagious cases should protect his clothing by donning a gown like a "duster," which can be discarded immediately on leaving and then subjected to the sterilizing influence of boiling water, direct sunlight, or formaldehyd gas. In the city of Philadelphia a sterilized gown in an appropriate container is sent by the Bureau of Health to each house from which a case of contagious disease is reported. This gown is for the use of the physician while in attendance upon the case. When not in use the gown is kept in its container and is sprinkled with about a teaspoonful of undiluted formalin before the container is closed. Tests show this to be sufficient to disinfect the gown by the next visit of the doctor. After recovery of the patient the gown is called for and laundered by the health authorities. Inasmuch as there is a possibility of conveyance of infective material from the floor on footwear, as demonstrated by Dr. F. P. Denny, it is advisable, in certain cases, that the attending physician pay particular attention thereto.

PROTECTIVE INOCULATIONS

In a category somewhat different from that including the prophylactic use of specific antitoxins in protecting from diphtheria and tetanus and vaccination against small-pox, as mentioned elsewhere, belong the so-called protective inoculations with bacterial vaccines. For some time this subject has received considerable attention, and sufficient advance has been made to warrant the statement that, within limits, protective inoculation is a practical procedure which, without injury to the patient, affords him more or less prolonged protection from certain infectious diseases to which he may be exposed. The methods used and the principles involved may be stated briefly: A living culture of the causative agent of the disease in question is killed by heat. This dead culture is then injected subcutaneously into the person to be protected in a dose sufficient to excite mild local and constitutional reactions, lasting for from twenty-four to thirty-six hours. These are manifested by slight swelling and reddening at the site of inoculation, a little fever, some degree of muscular pain and more or less headache; one or all varying with different individuals. This group of phenomena is regarded as specifically related to the material injected and is interpreted as being, in reality, a modified form of the disease from which the individual is being protected. With recovery from these symptoms a very large proportion of treated persons exhibit a marked degree of immunity. This may last for a few weeks or several months, as the case may be. While experimentally such inoculations have been shown to be effective for many infections, in actual practice on man their use has been principally in protecting from bubonic plague, Asiatic cholera, and typhoid fever.

Without taking up a detailed analysis of the returns from these inoculations it will suffice to say that where they have been practised on large numbers of exposed individuals, as in India, South Africa, and the Philippines, there have been in the case of cholera and plague about 50 per cent. more deaths and 70 to 80 per cent. more cases among the uninoculated than among those who submitted to the protective treatment; while in the case of typhoid fever, to quote Colonel Leischmann, there have been about ten times as many cases and deaths among the uninoculated as among the inoculated. These results are, throughout, so impressive, the underlying principles on which the method rests are so firmly grounded in experimental proof, and the risk to the individual is so insignificant that one might be tempted to regard the routine adoption of such protective inoculations as necessary to a modern scheme of prophylactics for all diseases the causes of which can be isolated and cultivated. Whether so general an application of the method is ever to be made remains for the future to determine. In so far as the diseases mentioned are concerned, however, the method may be considered as an appropriate part of the general measures for preventing their occurrence, especially among individuals thrown together under the circumstances of military and

contract camp life, those residing in or about to visit countries or places in which those diseases are endemic or epidemic, and those whose duties bring them in constant contact with patients suffering from one or the other of those maladies.

Of the diseases mentioned, typhoid fever is by far the most important. It is practically everywhere, its origin and spread are favored by ignorance and the careless habits of the people of every country and clime, and, as the records show, it has caused to those responsible for the health of men gathered from all quarters and suddenly thrown together under such rapidly extemporized conditions as are peculiar to to camp life more concern than any or all of the other acute infections.

It is natural, therefore, that the method of protective inoculation should have been given a careful trial upon troops being sent to the field. Here success has been so general that the practice of antityphoid inoculations is either in vogue or in contemplation by all progressive governments.

But its use is not of necessity limited to this sphere. In civil life there are indications in abundance calling for its employment. There is, for instance, scarcely a hospital in any community where the disease prevails that does not have on its sick list in the course of a year one or more nurses or other attendants ill of typhoid fever. The histories of these cases leave little room for doubt that the disease was contracted, in some cases at least, from typhoid patients in the performance of duties within the hospital, and this, too, in spite of instruction as to the personal measures to be taken for self-protection. For those so occupied protective inoculations constitute a safeguard of the greatest value.

It must be borne in mind, however, that though protective the protection afforded by these inoculations is neither certain nor lasting in all cases. Some individuals are less certainly protected than others and some acquire protection of shorter duration than others. The method should never supplant, but rather supplement, the well-established procedures that make for good general sanitation.

DISINFECTION

Disinfection, the destruction of pathogenic organisms, is the most important of the artificial defenses against disease; and yet, in spite of its recognized importance, there is hardly any division of preventive medicine that is administered with so little intelligence. The reasons for this are, doubtless, many. Before the discovery of the nature of infective material, strong-smelling materials of various kinds were supposed to be endowed with anti-infective properties, and these were attributed also to a wide variety of chemical salts, especially to those whose solutions were known to act as deodorants. The work of Koch, Wolfhügel, and their associates, in 1881, demonstrated the absolute uselessness of many of the theretofore trusted agents; but, at the same time, through erroneous experimentation,

it established fallacious standards of efficiency which, later, were repudiated by their authors, who very properly modified some of their original conclusions. Unfortunately, in science, as in daily life, the publication of error can rarely be counteracted by tardy, or even prompt, retraction. And so it happened that the surprising results of the earlier workers in the field of disinfection were accepted as authoritative, and the subsequent modifications had much less influence.

To the layman and, indeed, to the average busy practitioner, to whom the clinical side of medicine is infinitely more interesting than the results of pure laboratory research, disinfection is an exceedingly simple matter; to the laboratory worker it has its complex side. If all organisms were equally resistant, and if all germicides were equally aggressive under any and all circumstances, disinfection would be simplicity itself; but when we know that not all species and not even all strains of one species are alike in resistance; that some very virulent organisms are destroyed very quickly by weak agents, in which other less harmful species can live for days; that coincident conditions of heat and cold, dryness and moisture, light and darkness, may, each in its own way, exert a large influence; that one agent can kill a dried organism of high resistance almost instantly and be almost powerless against it when wet, while, on the other hand, another agent may work in vain against the same dried germ for days, and destroy it in a few seconds in the presence of water; and that one is never wholly safe in reasoning by analogy in a field in which the factors are so diverse, it must be clear that the principles and practice of disinfection are deserving of greater attention than the profession has given them.

The idea of instantaneous action seems to have secured a strong hold in the minds of most persons. One sees the professional man dip his hands for a second or two into a disinfectant that cannot kill the ordinary pyogenic organisms in thirty minutes, and, provided he dries them with a sterile towel, he is content. One sees the nurse wipe up infective matter with a cloth moistened with an ill-smelling turbid liquid, and deposit the cloth in an appropriate receptacle, which, later, will be burned with its contents; she is conscious of duty well performed, but the spot may be inhabited by millions of living organisms in spite of the treatment. A reasonable length of contact is necessary, even with the most powerful of germicides, for only in certain cases and under certain favoring conditions do disinfectants act immediately. If one knows exactly with what species one has to deal, and also the exact conditions obtaining, it may be possible to count on almost instantaneous action; but, as a rule, time is not so important a factor: the practitioner can expose his hands a few minutes in a more effective solution; the nurse can wet the infected spot and let the agent perform its office.

It would appear to be hardly necessary to speak of the importance of choosing as a disinfectant an agent that has stood the test of

laboratory investigation; and yet, how many give the matter of choice any thought whatever? It is a singular fact that, in the exploitation of a disinfectant, the essentials to success are a meaningless name, advertising, and adherence to the orthodox method of wrapping the container. The name may or may not be suggestive of germs and their destruction; the advertisements should be, in part, at least, in medical periodicals; the bottle must be very closely wrapped, so that no part of the glass is visible, and the wrapper must be affixed with paste, so that it will not become loose. The evolution of the package is simple; the first in the field adopted the method, later comers copied it, and some have impressed the emblem of the Geneva Convention to attract the eye and stimulate the imagination. The assertion that the contents of the bottle will kill any and all infective agents under any and all conditions is accepted, as a rule, without question; and, provided the bottle is properly dressed, sea-water could easily win a brevet rank of disinfectant. That so little discrimination is shown in the choice of germicidal agents must be responsible for much harm, since most of the proprietary preparations, if not all, are incompetent to perform the work for which they are employed. To those who are not attracted to secret preparations thus presented, another class commonly appeals. This includes a variety of strong-smelling by-products of unknown and complex chemical composition. Most of them in common use are germicidal to a certain extent; some of them are fairly rapid, and others are very slow, while a few are inert; but all of them possess the tarry odor which appeals so strongly to the imagination, and it is persistent on the hands and on other surfaces to which they may be applied.

In the practice of disinfection it must be borne in mind that the operator needs a head as well as hands. There is no universal disinfectant suited to all conditions, and especially to all objects capable of becoming infected. One cannot treat a velvet dress and a typhoid discharge by one and the same method, and the typhoid germ does not need to have brought against it the forces that would be required to destroy anthrax spores. Here a gas may serve; there, a liquid; this can be exposed to the sun and air; that should be burned. Whatever the agent employed and whatever the method followed, the element of time must be given due consideration, and although it may have been proved by laboratory experiment that a given agent in a given strength of solution will destroy a given species on silk threads within fifteen minutes, it must be kept in mind that under other conditions a much longer exposure may be necessary, and that under certain circumstances no effects whatever may be produced, no matter how long the exposure. A certain organism, for example, is destroyed by corrosive sublimate solution within a few minutes, provided it is exposed in a fairly clean condition; but the presence of fatty matters may prevent contact or retard action, while albuminous substances and various other matters will precipitate the disinfectant, and thus put it entirely out of action.

Temperature also is a factor not to be lost sight of in certain cases. Thus, a difference of a few degrees in temperature makes a very marked difference in the efficiency of carbolic acid; and in formaldehyd disinfection in winter it is far more important to heat a room than to use a much larger amount of the gas than would ordinarily be employed.

The influence of moisture is very variable. In a state of absolute dryness all micro-organisms and spores will doubtless perish, but absolute dryness is not easily produced. Exposed to the air, even to very dry air, such as that of most of our houses in cold weather or that of arid climates, like Arizona, absolute dryness cannot be attained, because the driest of air contains some moisture, and because the envelop of the bacterium protects the protoplasm from loss of moisture. Even hot, dry, road dust contains an appreciable amount of hygroscopic moisture, which needs no protecting envelop to prevent its loss. But in a state of comparative dryness, most organisms are less resistant to most germicides, but not to all. Dried pyogenic organisms will succumb quickly to very weak solutions of corrosive sublimate (1 : 5000, for example), while the same organisms, from the same bouillon cultures, in a wet condition are less readily affected; on the other hand, these same dried germs may live for a day or more in absolute alcohol, which will kill them, if moist, within a few minutes; and gaseous disinfectants require the presence of an abundance of aqueous vapor for their best results in house disinfection. The typhoid bacillus cannot long withstand ordinary air-drying unless protected by enveloping material of a hygroscopic nature, and bacilli of bubonic plague and of cholera are even less resistant; the bacillus of tuberculosis withstands drying for months, and the spores of anthrax have been known to preserve their viability for longer than eighteen years.

Agents Employed in Disinfection.—Disinfectants may conveniently be divided into two classes: physical and chemical. The former include heat and light; the latter, gases and liquids in great variety. No substance in the solid state exerts any important and extensive bactericidal action.

Heat is one of the most important agents which can be employed, but dry heat is far less efficacious than moist. The action of hot dry air depends probably on the abstraction of moisture from the bacterial protoplasm, and this, as has been said, is protected by the cell envelop. Dry heat is not suited to the general purposes of house disinfection, because the high temperature required exerts an injurious influence on most household articles which need to be disinfected. Beyond 230° F., the fibers of all textiles are made brittle within a short time, and even at 300° F. not all organisms are destroyed within two hours. Moist heat, on the other hand, is very efficacious, and moistened hot air—that is to say, hot air containing from 55 to 65 per cent. of the amount of aqueous vapor which it can hold—is far more efficient at 212° F. than dry hot air at much higher temperatures. Indeed, it

is far better adapted to the treatment of woolen materials than the much more quickly germicidal agent steam, as will be shown. For some of the purposes of disinfection steam under slight pressure is the ideal agent. The needed exposure is short, and the process, when properly conducted, is sure in results. Articles of cotton and linen are in no way injured, but woolens are made to shrink, and while in the case of blankets this may not be a serious matter, in the case of garments the change may considerably affect fit and general appearance. For all-wool clothing, therefore, moistened heated air is much to be preferred. Thus, I (Harrington) exposed two new coats to the action of steam under ten pounds' pressure for ten minutes. Cultures of Staphylococcus pyogenes aureus and albus, Bacillus pyocyaneus, and Bacillus diphtheriæ on silk threads inclosed in sealed envelops, which were placed in the various pockets and in the sleeves, were killed, but the coats suffered a considerable shrinkage. Next, ten coats of different kinds and materials, from dinner coats of broadcloth to overcoats of kersey and frieze, were exposed, similarly stocked with cultures, to an atmosphere of heated air and aqueous vapor at 210° F. for one hour. Every culture was killed, and not a garment showed the slightest injury. The advantage of the presence of aqueous vapor in the heated air lies, then, in the fact that the time of exposure is shortened and that effectiveness is secured. Again, this means is suited to the treatment of certain articles which cannot well be exposed to the influence of very hot, dry air, or to that of steam; thus, articles of leather, such as gloves, shoes, leather bindings, and furs, can be exposed to heated moistened air at 212° F. for as long as six hours without injury.

For the work to which it is suited steam is ordinarily the best agent, since it acts very quickly, and, when properly applied, will destroy the most resistant spores within a few minutes. The higher the temperature of the steam, the more quickly it acts; but superheated steam which has such a temperature that it will not condense within the fibers has no advantage over any other dry gas. It is the most useful agent in the preparation of surgical dressings and for sterilizing instruments, towels, and operators' gowns in hospital practice.

Naturally, to get the best results, special forms of apparatus are needed, and consequently steam disinfection is not to be thought of as practicable in the home. Autoclaves of various sizes and of different forms, according to the purpose to be served, are used extensively in hospitals, quarantine stations, and public disinfecting plants. Although there are many types, they are based upon the same principle. They consist of a chamber, into which the infected objects are introduced, and which is connected with a boiler by pipes controlled by valves. The apparatus acts with highest efficiency if provided with means for withdrawing the air after the chamber is filled. This can be brought about in two ways: either by the use of a steam jet or an air-pump. The reason for the high efficiency in the presence of a vacuum lies in the fact that the contained air will act as a cushion and

prevent the steam from coming into the close contact which is required. In 1881 Koch overlooked the influence of air in the chamber and concluded that steam at 120° C. was inferior to streaming steam. Heidenreich showed, six years later, that the reason why a liter flask of water, exposed by Koch for one-half hour to steam at 120° C., attained no higher temperature than 85° C., was that air was present and acted as a cushion. He repeated the experiment, but drove out the air, and his flask of water attained the desired temperature within five minutes. In other words, he secured within five minutes a temperature 35 degrees higher than Koch had been able to secure after thirty minutes.

In hospital practice, dressings, towels, etc., are ordinarily exposed to steam under ten or fifteen pounds' pressure for upward of an hour; and in some institutions, sterilization of the same lot of articles is repeated in twenty-four hours. While this works no injury to the objects exposed, it is a useless expenditure of time, since they can be sterilized within fifteen minutes under ten pounds' pressure. Fractional sterilization of dressings and towels is absurd, and is based, without proper thought, upon the practice followed in sterilizing milk. Here we have a material rich in nutrient matter and in hardy bacteria which form spores. Today we destroy the bacteria, but the spores escape; tomorrow the spores develop into bacteria and are less resistant. A second exposure will kill them; but in the case of bandages, dressings, towels, etc., we can have at best some non-pathogenic, very resistant spores, and should they escape the first day's steaming, they would be equally prepared to escape that of the second, inasmuch as there would be neither moisture nor food material to lead them to proceed from the spore stage to that of full development. Spore formation in bacteria, like seed formation in higher plants, is a natural means of perpetuating the species. Under adverse conditions of drought or lack of nutrition neither seed nor spores succumb so readily as do the plants or the bacteria when in the growing state.

In operating a steam sterilizer of small size, such as is used in hospitals, the air can be got rid of by opening the vent pipe after the steam has been turned on for a short time and allowing it to escape. By repeating the operation several times we may be sure that but a small portion of the original aërial contents of the chamber remains. In operating a large machine, such as is used in quarantine stations and in public disinfecting stations, the air is removed by means of a steam exhaust until a vacuum of about twenty inches is attained. Steam is introduced under a pressure of about fifteen pounds, and after an exposure of about fifteen minutes the steam exhaust is again brought into play; and after another short exposure, the inlet for fresh air is opened, and a current of air is drawn through the chamber for about ten minutes, after which the contents are removed and exposed to the air. Even though considerable steam may have condensed within the fibers of the articles exposed, the latter are, as a rule, quite dry within a few minutes.

Unless a partial vacuum is attained—and the more complete the vacuum the better—the results are likely to be rather uneven. When very large and bulky articles, such as rolled carpets and mattresses, are treated, a pressure higher than fifteen pounds should be employed; and in all cases close packing should be avoided. There should be abundant opportunity for steam to circulate between the objects exposed, and yet one sometimes sees an autoclave in the sterilizing room of the hospital so closely packed as hardly to permit of the introduction of a knife-blade between the objects.

It is commonly stated that steam has no injurious effect on articles of clothing. As stated above, woolen goods will not withstand the influence of steam. Not only are the fibers shortened, but the interstitial spaces appear to be increased; the thickness of the goods is increased at the expense of area; and the color does not always escape injury, for some light grays are likely to take on a yellowish-brown tint.

Next to steam in efficiency comes boiling water, which is suited to instruments and infected cotton and linen clothing and other white goods. Boiling for half an hour will kill the most resistant pathogenic bacteria and spores. The fact that certain non-pathogenic spores can withstand boiling is of no particular consequence in ordinary disinfection, since their full development afterward will cause no injury. In ordinary food materials the presence of these hardy spores may be of importance; in practical disinfection, this can always be left out of account. The pathogenic organisms with which we commonly have to deal are destroyed within a very few minutes by boiling water. Staphylocccus pyogenes aureus, for example, is destroyed within two minutes.

Inasmuch as boiling water tends to fix stains caused by bloody, fecal, and other discharges of the body, it is best to soak the objects first in cold disinfecting solution, such, for instance, as a 2 per cent. solution of carbolic acid.

Cold.—While cold inhibits bacterial activity, it is in no sense a disinfectant in the usual meaning of the term. It is true that, after varying periods, bacteria in ice tend to lose their vitality, but typhoid organisms have been known to survive in ice for nine months, and even the very low temperature of liquid air does not suffice to kill them in a week or even longer.

Direct sunlight has been shown to possess bactericidal action on pathogenic organisms. It retards growth and, after a time, which varies according to the nature of the organism and the circumstances under which it is exposed, it kills them. In order for this to occur, however, the bacteria to be killed must be freely and fully exposed to the direct rays. The least shadow interferes with the sun's action. In consequence of this it is doubtful if sunlight can be regarded as a practical germicidal agent, in the ordinary sense of the word. Experiments made under laboratory conditions, where all factors can be so adjusted as to favor the demonstration, show that the bacillus of

tuberculosis is destroyed by direct sunlight more or less quickly, according to the thickness of the protecting mucus in which it is incased. The typhoid organism, the staphylococci, and even the very resistant anthrax bacilli and spores succumb to its influence. For the action of the sun's rays, however, free access to air is necessary. If air is excluded, the influence may be very slight or even wanting. Electric light has some bactericidal action, but it is much less than that exerted by direct sunlight.

Chemical Disinfectants.—Coming now to the chemical disinfectants, while it must be admitted that a very large number of chemical compounds exert a certain amount of action on some bacteria, but very few of them can be classed as efficient general disinfectants. Some will kill any kind of organism under some circumstances and fail under others. Thus, while corrosive sublimate has a very strong germicidal influence under favoring conditions, its influence is very much opposed by the presence of substances with which it can form insoluble precipitates or coagula, which may act as a preventive to its further influence against the organisms immediately beneath. Some chemical agents act on the protoplasm directly; some change the reaction favorable to the growth of the particular species; some destroy the nutritive material which the organisms require; some take away the oxygen which they need; some bring in an excessive amount of oxygen, which acts adversely; some that are very efficient in the laboratory cannot be employed in general work, because of their destructive influence on substances with which they come in contact. Thus, the strong mineral acids and caustic alkalis are very efficient germicides, but they exert so destructive an influence upon most objects with which they come in contact as to preclude their use, even when considerably diluted.

It should not be lost sight of in practical disinfection that the various agents possess different degrees of bactericidal power, and hence may not all be used in the same concentration; some must be used in fairly strong solution; others are efficient when greatly diluted; some will exceed others in efficiency, although applied in less than one one-hundredth or even one one-thousandth of the strength.

As has been suggested above, the length of contact of the germicide with the infective material is of much importance. Many agents are efficient if they are allowed sufficient length of contact; and in gross disinfection instantaneous action is practically out of the question.

While very many substances possess bactericidal properties, there are really but few which should be employed in gross disinfection. Above all, one should avoid the proprietary disinfectants above mentioned, for two reasons: namely, their cost and their probable lack of efficiency. They are not to be regarded as in the same class with patent cure-alls, for they are made, as a rule, in good faith, but not according to modern knowledge concerning disinfectants. They are made of substances which formerly were, and to a great extent now

are, considered by some to be effective agents; for example, zinc chlorid, aluminum chlorid, ferrous sulphate. Some of these proprietary preparations will act sometimes, some of them will act rarely, on ordinary pathogenic organisms of a low grade of resistance. But it is not enough that a disinfectant may act sometimes or rarely, and against certain species of bacteria and not against most others. A disinfectant for effective general use should have sufficient power to destroy all the common pathogenic organisms. It is not necessary that it should have the power to kill the very resistant anthrax spores, which do not often enter into the question of house disinfection; but, in general, it may be said that any disinfectant which will destroy the pyogenic organisms, Staphylococcus pyogenes aureus, for example, will kill all the pathogenic organisms with which one ordinarily has to deal. In the minds of many persons a strong odor is a necessary characteristic of a disinfectant; but some very efficient disinfectants have no odor, and many strong-smelling substances have absolutely no germicidal power.

We must bear in mind that there are two kinds of disinfection: one in which time does not enter into account, and one in which rapid action is desirable. Thus, in the disinfection of stools, etc., hours may be at our disposal; but in surgical work one expects and requires rapid action. Consequently, what would be an absolutely useless preparation in surgical work may be very valuable for gross disinfection. If one were to ask a hospital surgeon if lime is a good disinfectant, he would regard the question as foolish; and it would be, if surgery were the only branch of medicine in which disinfectants were used; but the same question put to a military surgeon, to whom disinfection of excreta is a matter of highest importance, would call forth an emphatic affirmative answer. On the other hand, the hospital surgeon might praise lysol or sublamin, while the practical disinfector of houses would not for a moment think of using them in his work. For the purposes of this chapter we may omit the consideration of disinfectants suited to the needs of the operating theater, and confine ourselves to those applicable to processes of gross disinfection, that is, those used in the sick-room and for the disinfection of premises.

Almost every substance suitable to house disinfection possesses some disadvantage; they are either poisonous, expensive, corrosive, or smell badly. There is one which possesses none of these disadvantages; it has no odor; it is non-poisonous; it is exceedingly cheap; and it does not corrode—namely, common washing-soda. This was investigated, in 1903, by Simon, who, mindful of the fact that the hotter a disinfectant is, the better it works, bethought him to determine what happens when hot soda solution is employed in cleaning. (As an instance of increased efficiency with increased heat may be mentioned the fact that carbolic acid in its usual dilution is 50 per cent. more effective at 95° to 100° F. than at 60° F.) Washing-soda is used in every household as a cleaning agent, because it saponi-

fies grease and dissolves albuminous substances. Simon restricted the temperature of the solutions with which he worked to 140° F. and below, because that degree of heat is about as hot as a scrub-woman's hands can endure. He employed the substance in 2, 5, 10, and 20 per cent. solutions, at temperatures ranging from 72° to 140° F., and he tested their strength against staphylococci, streptococci, the bacillus of diphtheria, and tuberculous sputum. While at temperatures below 132° F. none of the solutions affected the diphtheria organism, the 2 per cent. solution killed it in two minutes and the 5 per cent. solution in one minute at a temperature of 132° F. The control organisms withstood the same temperature in distilled water for fifteen minutes and still retained their viability. Staphylococci resisted all solutions at all temperatures up to 140° F., but then they were killed in five minutes. Streptococci succumbed in less than five minutes, and dried tubercle bacilli were killed by the 2 per cent. solution in five minutes and by the 10 per cent. solution in one minute. Typhoid bacilli, colon bacilli, and Kruse's dysentery bacilli were killed within five minutes by the 2 per cent. solution at a temperature of 122° F. Thus, for general cleaning it would appear that soda serves two useful purposes: cleaning and disinfecting. It is recommended that woodwork, linoleum, and such objects as will suffer no injury through contact therewith be first washed with the soda solution, then allowed to dry, and then be washed again.

Caustic lime has long been known to have great destructive power on organic matter—so much so that in hot climates it is used to bring about the rapid destruction of the bodies of the dead. With one-half its weight of water it is slaked to a dry powder—the hydrate; this, when mixed with a fairly large volume of water, makes whitewash, and with smaller amounts of water—about three or four volumes of water to one volume of powder—it makes milk of lime, which is very useful for treating excreta. When stools are mixed with enough milk of lime to acquire a strong alkaline reaction, we may be sure that any typhoid fever germs present will be destroyed in about an hour. Even ordinary lime-water will kill typhoid germs after a few hours of contact, and hence one can readily understand how valuable an application the much stronger ordinary whitewash is. Lime has the advantage of being very cheap. Only that which has recently been slaked with water should be used; air-slaked lime is useless. The slaked lime, and whitewash and milk of lime made therefrom, should be kept covered, in order to exclude the carbonic acid of the air.

The so-called chlorid of lime is a very powerful disinfectant when brought into actual contact with bacteria. It is a white powder, fairly dry, and has a faint odor of chlorin. In the pasty condition, or with a strong odor, it is not acceptable, since these conditions show deterioration. Chlorid of lime is partially soluble in water. It may be triturated to a cream and then diluted. This breaks the compound up into a number of different substances, the important one of which is

hypochlorous acid, which becomes broken up into oxygen and hydrochloric acid.

A 5 per cent. solution of chlorid of lime will kill the very resistant anthrax spores in less than five hours, and almost all common bacteria within five minutes. The preparation recommended by the committee of the American Public Health Association is six ounces of powder of chlorid of lime to a gallon of water, which mixture is almost equivalent to a 5 per cent. solution. Chlorid of lime is not suited to the treatment of clothing, on account of its tendency to injure the fibers. It may sometimes be used in very weak solution, but this necessitates repeated rinsings with large quantities of fresh water. The use of the powder, as such, in privies and elsewhere is not to be recommended, since it gives rise merely to a disagreeable odor. A closely related preparation is the so-called chlorinated soda, or Labarraque's solution. This is used for the same purposes as the chlorinated lime. It is powerful, but more expensive; the active agent is the same as in the preceding—hypochlorous acid. According to recent experimentation by Andrewes and Orton, hypochlorous acid is an exceedingly powerful germicide, the pure acid, in 1 : 1000 strength, killing anthrax spores within a half-hour; but in the presence of organic matter, so unstable an acid is very readily decomposed and rendered inert, and hence any substance containing it must be used in fairly large amounts when organic matter, especially protein matter, is brought into contact with it.

Concerning other inorganic substances used as disinfectants, there is little to be said. The salts of iron, zinc, aluminum, copper, and manganese are very largely useless in gross disinfection, and many of them are expensive in addition.

Of all metallic salts, corrosive sublimate is the most efficient, but it is not so efficient as is generally supposed. At first, the power claimed for it as a disinfectant was marvelous, but the original investigators who placed it above all other disinfectants had later to retract much that had been said in its favor. Its principal use in disinfection is not in the gross disinfection of the sick-room and dwelling, but in surgical work in the amphitheater. It does not lend itself to gross disinfection for a number of reasons, one of which is quite sufficient to rule it out of sick-room disinfection; namely, that in the presence of albuminous substances and other material present in the excreta, it is precipitated from its solution and rendered inert. Another serious obstacle to its use is its corrosive action on plumbing.

Coming now to the organic compounds, we have to consider, first, a disinfectant which at one time was regarded as easily superior to all others, and later was dispossessed of its high position through the results of various experimental researches, which, to a certain extent at least, were faulty in technic and conclusions; but recently it has recovered to some extent its position, which has unsuccessfully been filled by a number of other well-advertised preparations. This

agent is carbolic acid. It fell from its high position because it failed to come up to the former requirement that an efficient germicide should destroy anthrax spores, without regard to its efficiency on organisms of a lower grade of resistance.

Carbolic acid has the advantage that it is not precipitated when brought into contact with albuminous substances, acids, and salts, and a still greater advantage in the fact that it kills all the common pathogenic organisms in a very few minutes when employed in the usual strength of 2.5 and 5 per cent. solutions. It has been held by some experimenters that a 5 per cent. solution is incapable of destroying typhoid bacilli, but this is hardly credible, since these organisms are very easily destroyed by almost all real disinfectants, and are very much less resistant than pus-cocci, which latter are destroyed with ease and despatch. In my hands (Harrington) a 2.5 per cent. solution killed Staphylococcus aureus, in three series of experiments, in less than four minutes, and Staphylococcus albus in less than one minute, Bacillus coli communis and Bacillus pyocyaneus in less than two minutes. The efficiency of carbolic acid is very much increased by warmth, and it is commonly asserted that it is increased also by salt and by mineral acids; but it is to be remembered that mineral acids themselves have very decided germicidal action, even in their weak solutions.

Crude carbolic acid contains a certain amount of cresols, and as these are regarded as more bactericidal than phenol, the crude acid is preferred to the pure, and it has the additional advantage of being considerably cheaper. The cresols certainly are exceedingly valuable and powerful. In my hands (Harrington) Staphylococcus aureus and albus, Bacillus coli, and Bacillus pyocyaneus were destroyed within two minutes by 2.5 and 5 per cent. solutions. Once, Bacillus pyocyaneus survived two minutes, but was killed within three. The fact that cresols are powerful agents has led to a general belief that the substances containing cresols are equally powerful. Among these substances are creolin, which is said to contain 10 per cent. of cresols; lysol, 50 per cent.; bacillol, 52 per cent.; solveol, 25 per cent.; solutol, 60 per cent.; as well as sulphonaphthol, germol, and a number of other by-products. But it happens that these various substances are not uniform in composition. Creolin, for example, may or may not have 10 per cent. of cresols; samples have been known to contain no cresols whatever and no phenol. So, too, the bacillol of one concern may be very different from that of another. The first named is commonly used in 2.5 per cent. and 5 per cent. mixtures with water, and even though it should contain 10 per cent. of cresols, it will be seen that, as used, the mixtures would contain but 0.25 and 0.5 per cent., and this may account for the fact that, in parallel experiments with the same organisms, the stronger of these mixtures required fifteen minutes to bring about sterility, while 2.5 per cent. of carbolic acid accomplished it within two minutes. It is said, however, that creolin does not depend wholly upon its contained cresols for dis-

infectant properties. Be that as it may, the cresols are the important constituents.

In the case of lysol, which is used also in 2.5 and 5 per cent. solutions, the specimen employed conformed to the statement concerning its composition. Practically the same is true of bacillol; but, as has been noted, bacillols vary. A specimen obtained by me and bearing an American trade-mark proved to be as efficient in germicidal work in 5 per cent. solution as a 2.5 per cent. solution of cresols. This would indicate that this particular preparation probably contains the advertised percentage of cresols. There is, as may be seen, a certain disadvantage in employing these cresol-containing preparations. With crude carbolic acid or with cresols themselves we know what we have in hand to start with. Both are very valuable in their effects, and in the matter of odor there is little choice.

The commercial 3 per cent. preparation of hydrogen peroxid has a powerful bactericidal influence, but it is inferior to phenol and the cresols. It is possible, however, to use it where the others would be inadmissible, as it is not poisonous and is not very irritant, even to mucous membranes. It can be taken into the mouth without danger. For gross disinfection it is altogether too expensive.

Alcohol in about 70 per cent. strength is a valuable disinfectant for surgical purposes, but it is too expensive and does not lend itself readily to the objects of gross disinfection.

Concerning soaps, the evidence of bactericidal value is very contradictory; but, on the whole, the preponderance of testimony is in favor. However that may be, one feels safe in recommending soap for general cleaning purposes, and can indulge the hope that it will exert not only cleansing, but disinfectant, powers. The addition of two parts of soap to each part of carbolic acid employed in solution is said materially to increase the germicidal power of the carbolic acid. Medicated soaps are found, as a rule, to be not more efficient as disinfectants than common soaps.

Next we have the various gaseous disinfectants. These include the active agent of fresh air, which is oxygen. It oxidizes organic matter and "sweetens" articles which are exposed to it. This is a matter of common knowledge, as is evidenced by the general and time-honored practice of airing clothing and bedding.

Chlorin acts as a powerful germicide in the presence of moisture. It decomposes offensive gaseous products and destroys disease germs, but it has the disadvantage of bleaching colored fabrics and injuring the strength of their fibers. The dry gas has no influence.

The fumes of burning sulphur have been employed from very ancient times for the general purposes of disinfection, but the experiments of Koch and his assistants revealed their inadequacy. The dry gas has no germicidal power, but in the presence of moisture the fumes may, or may not, destroy all organisms thereto exposed. It corrodes fabrics, destroys organic colors, tarnishes brass and silver, and imparts to bedding and similar material offensive odors which sometimes

require long exposure to fresh air to be dispelled. The practice of fumigating rooms with sulphur fumes has died out in all places where the public authorities are abreast with the times. The place of sulphur fumes has been taken by formaldehyd.

Formaldehyd comes into the market in the form of a concentrated solution of the gas. It cannot be stronger than 40 per cent., since this is all of the gas that can be held in solution by water at the ordinary temperatures. Attempts to concentrate it beyond this point cause the substance to polymerize and precipitate as a solid. This solid form is known as paraformaldehyd; it can be used in very simple forms of apparatus for the generation of the gas.

The gas is exceedingly irritant to the eyes and nose. It has a very strong affinity for organic substances, and combining with the foul-smelling products of decomposition, it acts as a powerful deodorant. It has no action on metals; does not affect the tensile strength of fabrics; works no injury to their colors, and has no injurious action on any objects which are exposed to its influence in the process of disinfection. It acts best in the presence of aqueous vapor, and, like all disinfectants, its power is increased by high temperatures.

For the disinfection of rooms formaldehyd may be employed in several ways, namely: The gas may be disengaged from its watery solution by heating; it may be liberated from its dried polymer, that is, paraformaldehyd, also by the application of heat; and it may be used in dilute solution directly as a spray.

In disengaging the gas from its watery solution several plans are in use. The undiluted 40 per cent. solution of the gas is heated to the boiling-point in specially constructed autoclaves or retorts and the gas, together with the steam generated, is passed into the sealed room by means of a tube directly through the keyhole or some other small opening. Satisfactory results have been obtained by simply boiling the undiluted solution in an open pan over a spirit or gas lamp in the room to be treated. By some it is held that the addition of about 10 or 15 per cent. of glycerin to the solution before boiling is commenced aids in disengaging the gas by raising the boiling-point of the solution. Where this method is employed, the amount of formaldehyd solution necessary is not less than one pint to each 1000 cubic feet of air-space in the room to be disinfected.

In liberating the gas from the solid paraformaldehyd through the disintegrating action of heat, the solid tablets in sufficient number are placed in open metal trays over properly constructed spirit lamps and moderate heat is applied until the disintegration is complete. When thus liberated the gas is dry and only moderately effective, therefore, as a germicide. To increase its action moisture is necessary. This may be provided by heating coincidently water in an open pan over another spirit or gas flame. There are on the market specially constructed lamps by which the two operations are conducted simultaneously over the same flame. If this plan be adopted, about sixty

"pastils" of paraformaldehyd must be decomposed for each 1000 cubic feet of air-space to be disinfected.

By the direct spray method, a mixture of water and the saturated watery formaldehyd solution is made in the required strength. By means of a powerful atomizer this solution is then projected over all surfaces of the room, particularly the beds and the horizontal surfaces on which dust and infective particles are likely to have fallen. The strength of solution used in this method that has given the most satisfactory results is equal parts of formaldehyd solution and water in the proportion of three pints of this mixture for each 1000 cubic feet of air-space to be disinfected. When this method is employed, there are several points to be borne in mind: The atomization must be perfect, that is, the solution must be projected in a fine cloud; the atomizer must be of such strength as to project this solution a distance of five or six feet; the solution must be applied by hand to all the surfaces in the room, particularly horizontal surfaces; the bedding, each piece in turn, must be sprayed and removed from the bed and piled on the floor. Where this method is employed, it is found that by attention to details from 98 to 100 per cent. of test objects placed in the room are invariably killed, and it has furthermore been found that if the bedding be sprayed as indicated above it is not necessary to subject it to subsequent steam disinfection. While the method has the disadvantge that it is rather hard on the operator, still it has advantages. There is no burning object left in an unattended room; we secure the direct action of the solution on infected objects together with the gas in a moist state that is disengaged from the solution; and, finally, by the intelligent application of the method the subsequent steaming of bedding, carpets, and other articles is rendered unnecessary.

There are other methods of generating formaldehyd gas without the employment of apparatus, but they have not all as yet stood the test of experience. In one, a briquet is used which contains a core of 50 gm. of paraformaldehyd; one briquet is used for each 1000 cubic feet. Also pastils are made with paraformaldehyd and caustic lime. When these are brought into contact with water, they evolve the gas and steam through the process of slaking. By another process the liquid formalin is dropped onto unslaked lime, and the heat caused by slaking sends forth the gas, but a part of it becomes decomposed. By another method the undiluted liquid is poured upon crystals of potassium permanganate. A violent reaction with generation of heat ensues. The heat disengages the gas from the solution, but at the same time oxidizes a part of it so that the amount of gas available for disinfection is somewhat lessened. Where this method is employed, a pint of the undiluted formaldehyd solution is poured upon six and one-half ounces of potassium permanganate crystals. This amount serves for the disinfection of 1000 cubic feet of air-space. It is most effective when the air in the room is rendered moist by boiling some water in a kettle or pan.

As to the germicidal influence of formaldehyd, there is no dispute. It will kill anything in the form of bacteria that it can reach, but its penetrating power is limited. If, in sufficient concentration, it can come into actual contact with bacteria, and if the air contains the required aqueous vapor and the temperature is not very low, it will kill the most resistant bacteria within reasonable time; but it has no more power to penetrate into the interior of compact bundles, mattresses, and other objects than any other gas. Into a loose package of crumpled muslin, for example, one may expect it to penetrate, but if the muslin be made into a compact bundle, penetration cannot be expected.

Formaldehyd is poisonous to all forms of vegetable life. Though intensely irritating to the eyes and throat, it does not appear to be poisonous to man or animals, certainly not in such amounts as would be inhaled in the course of ordinary disinfecting work. For certain individuals an exposure to either the gas or its solution results in troublesome inflammation of the skin.

The volatilization of a pastil or two in a sick-chamber is for certain individuals not disagreeable, and while it can have no great influence in disinfection in such small amounts, it improves the quality of the air by destroying disagreeable odors; in other words, it "freshens" the air.

For the killing of mosquitos, insects in general, and vermin formaldehyd is almost useless. Sulphur fumes are far more effective.

The disadvantages attending the use of formaldehyd are its expense, the odor, which sometimes is persistent, especially in the case of rooms with damp floors and walls, and its irritant effects to the eyes and noses of occupants of other rooms into which it is likely to leak. The odor can be overcome by the use of ammonia, and this is employed by many in addition to aëration of the room. Where the gas has been taken up by moist walls and floor boards, ammonia acts very advantageously, since the two gases neutralize each other and form a compound which has no odor. The great advantages of formaldehyd are its pronounced germicidal power and its harmlessness to the objects which are exposed to its disinfecting influence. The amount of formalin required is commonly held to be about one pint for each 1000 cubic feet. If paraformaldehyd pastils are employed, about sixty are required for the same space.

In the preparation of the room for gaseous disinfection it is necessary to close up all avenues of escape of the gas. Ventilation inlets and outlets must be closed as completely as possible; the cracks around windows should be closed by means of wedges to bring the sashes into close contact, or the cracks may be plugged with wet cotton introduced with a knife-blade or with putty; adhesive paper is useful for the stopping of cracks in general, especially around doors, and for stopping key-holes. If a stove is present in the room, the dampers should be closed, so that they may not permit ventilation. Should the house happen to be wired for electric lights, an electric

fan is of advantage in the room, in that it can keep the air in motion and insure a thorough mixing of the gas in all parts.

The doors of all closets, and the drawers of bureaus and other furniture, should be wide open. Clothing should be hung as loosely as possible; mattresses should be pulled off the bed and put on edge. Everything that is to be acted upon by the gas should be so arranged as to make contact as easy as possible. The exit door should be closed and sealed with gummed paper.

It is customary to leave a room overnight, but it is not wholly necessary, and, indeed, it is often a hardship, especially in the case of poor people. It is possible to disinfect in the morning and to open the room in the latter part of the day, and have it ready for occupancy the same night.

It is not safe to count upon thorough disinfection of a mattress that has been grossly soiled by infected material by any process other than steaming, unless the contests are removed and thoroughly exposed to the action of the gas. There are some things that it is better to burn; for example, a straw mattress or one of excelsior; and other cheap objects that have become infected may more cheaply be burned than treated. Again, one must be reasonable in the disinfection of a room; if there happens to be a sofa in the room, it does not at all follow that its interior has become infected, and, in fact, it is more probable that any infective matter is resting lightly on its exterior, where it can be destroyed by the gas, for bacteria do not of themselves work their way between the fibers of upholstery. If they are not forcibly introduced, or if they do not gain access in suspension in a liquid that can penetrate, the chances are that the interior of a sofa will not receive any of the infective matter given off by the patient.

Formalin is used extensively for other than aërial disinfection. In making dilute solutions it is to be borne in mind that 1 per cent. of formalin and 1 per cent. of formaldehyd are not the same. Formalin contains only 40 per cent. of formaldehyd; consequently, a 1 per cent. formalin solution represents 0.4 per cent. formaldehyd, and a 1 per cent. formaldehyd solution represents 2.5 per cent. of formalin. One part of formalin in 20 of water is a valuable disinfectant agent for sputum in tuberculosis, for diphtheric membranes, liquid stools, and urine. While smaller amounts can bring about the desired results within reasonable limit, it is well to use equal volumes of the material to be disinfected and of the solution; in this way we insure that the combined volume will have a 1 per cent. formaldehyd strength. It is well to leave the articles in contact for an hour or two to insure sterilization.

In the disinfection of discharges from the bowels in typhoid fever, dysentery, Asiatic cholera, and tuberculosis of the intestinal tract, thorough mixing should be effected. Formalin is not the only agent that can be used for this purpose. Milk of lime is very efficient, but it leaves a bulky residue, which cannot be disposed of in the usual way, since it would have a tendency to form deposits in the traps.

Solution of chlorid of lime is efficient, and 5 per cent. solution of carbolic acid or of the cresols may be employed.

In the disinfection of urine in typhoid fever and tuberculosis of the urinary tract either carbolic acid in 5 per cent. solution, cresols, or formalin solution can be employed. In the disinfection of sputum we may employ carbolic acid or cresols or 5 per cent. formalin. Woodwork, such as water-closet seats, etc., may be treated with 5 per cent. formalin, carbolic acid, or cresols.

The question often arises, how far the process of disinfection should properly be carried in a house in which a dangerous infectious disease has occurred. This depends upon circumstances. Naturally, the principal consideration is the extent to which a house may have become infected. Instances are not uncommon in which a person, before being obliged to take to his bed, has gone freely to various parts of a house, although already sick with a contagious disease; or has been permitted to go about before convalescence has become fully established. Again, it is exceedingly common for members of the family and attendants to go from the sick-room to all parts of the house without any restriction whatever. In such a case it is possible, of course, that the exciting cause of the disease may be spread into every room and corridor, and then adequate disinfection requires treatment of the whole house. Overlooking this fact is responsible for much disinfection which is worse than useless, inasmuch as the disinfection of the sick-room alone does not destroy the infective germs in other parts; the occupants are lulled into a sense of safety, yet may receive infection in almost any room other than the disinfected one.

These considerations, together with others that are mentioned in the foregoing pages, clearly indicate the great desirability of hospital treatment for contagious diseases. The necessary safeguards can rarely be enforced in private residences and never in the overcrowded houses occupied by the poor. In so far as contagious diseases are concerned, there is no prophylactic factor of equal value to the public health as properly constructed, conveniently located, and adequately manned hospitals for the isolation and treatment of dangerous transmissible diseases. They are not only of advantage to the public, but clearly so to the patient, for in such hospitals he receives the benefit of care by those specially trained in the safe and proper management of types of diseases only occasionally seen by the general private practitioner.

THE GENERAL PRINCIPLES OF DIETETICS

By David L. Edsall, M.D.

A generation ago or thereabouts scientific knowledge of dietetics was so limited that in most particulars the methods upon which this division of therapeutics was based could have been devised by the intelligent and observing layman almost as well as by the physician. Indeed, even down to that time there had perhaps been written no more wise and philosophic discussion of the subject, so far as it went, than the little treatise of Cornaro, a layman, whose remarks, which are still very convincing, even though made nearly four hundred years ago, were based simply upon observation and reflection. The natural consequence of a lack of any principles that were founded upon sound scientific studies was that the teaching and practice of the subject were very largely the result of experience, together, often, with a great deal of speculation and personal fancy; and all these varied in their value simply in accordance with the degree of insight and common sense possessed by the individual teacher or practitioner. Such has been the case with most branches of science in the course of their development, but it has been very striking with dietetics and very persistent, and even to the present time the practical methods generally employed have always been relatively further behind contemporary scientific contributions than has been the case in any other important part of medical practice. The reason for this has lain in the point of view of the profession. Dietetics has been very largely looked upon as a minor part of treatment, and hence very naturally no serious study was given to it by the great majority of physicians. In a large proportion of instances, indeed, dogmatic statements of favorite authors in regard to the diet suitable in particular diseases comprised the sole knowledge of the subject, and, indeed, almost the sole interest in it.

Now that there is a much more wide-spread comprehension that dietetics is one of the most generally potent factors in treatment that we possess, and often the most important, there is a coincident realization that, as with the study of drugs, or, indeed, of anything else, we must devote some serious attention to the subject before we can employ it skilfully in practice, and we must particularly start with a reasonably good comprehension of the most important of the principles of the physiology of nutrition before we can reach any understanding of its pathology or can hope for frequent success in treating nutritional derangement, whatever its kind. For this reason much of what I shall have to say must be a sketch of a few

important physiologic facts, necessarily brief and limited to those that have important clinical bearing, and that are, therefore, valuable to us as a source of principles of practice; while together with these there are various things that are important to keep in mind constantly, that are derived from common observation and common sense, rather than from exact laboratory or other studies. These mingle constantly with the more purely scientific facts, and must do so. Each of these types of facts has often been much neglected by different sorts of writers, and perhaps at the present day, in physiologic discussion particularly, the latter are most commonly neglected —quite naturally so, since the physiologist's life does not bring him in contact with them. By using knowledge of these two types carefully we can now construct a system whereby we can reach the major conclusions in dieting our patients in a rational manner, even though there is still a very great deal that is unknown or unsettled. Concerning very many of the smaller details in dietetics we know very much less than we do in regard to the general principles, but, fortunately, serious errors are far less likely to occur if we proceed on sound principles, with relative ignorance of details, than if the contrary is true.

We need, first of all, to have general standards which will permit us to determine that we are within safe bounds in what we do, and not in danger of doing our patients harm by a dietary too sparing or too generous, either in its total bulk or in the main classes of food, namely, in protein, fat, or carbohydrate. In this connection we must first comprehend what the clinical function of these standards is, and not get into a temper with them, as some persons do, because they do not see their real purpose; and, on the other hand, we must not attempt to follow them too strictly, as we should do if we adopted the same attitude toward them that physiologists necessarily have in doing pure investigations. Even from the physiologic standpoint they do not constitute inflexible standards. They are simply averages obtained from very precise metabolic studies of a relatively small number of persons, and from very careful observations of the habits of large groups of people. They may be compared to the standard doses of drugs in that they can be varied considerably if circumstances indicate it in accordance with the individual patient and his condition, not only without doing harm, but with benefit. In all normal persons decided variations, of course, occur frequently for short periods; and for long periods, indeed, throughout their lives, many people will be found to live on quite widely differing quantities of food and, nevertheless, remain perfectly healthy. We cannot, therefore, consider these standards to be laws that must be followed strictly. This is often more true in disease than in health. Frequently we not only may, but must, modify our regulations in accordance with the individual's special kind of disturbance. In regard to the total quantity of food, for instance, whatever may be indicated by the physiologic standards,

we must go above or below what seems theoretically correct in many causes because of dangers that are even greater than a considerable excess or deficiency; we need, that is, to consider diet from the standpoint of a general knowledge of disease, as well as from a knowledge of physiologic requirements. For example, in many acute diseases in which gastro-intestinal disturbance is present, or is very likely to occur, as is the case in typhoid fever most commonly, we must often permit a little emaciation to occur during the height of the disease, because the danger from this is less than the danger from decidedly disturbed digestion, and the digestion will not stand even a normal amount of food in many instances. It appears to me to be very irrational in such cases to insist upon a full quantity of food. Still more irrational is the advice that we have repeatedly had recently, on the ground of experimental studies that show the possibility of accomplishing this, that we should give more than the normal quantity in such conditions, in order to cover the tissue loss produced by the disease. Unquestionably it would be advantageous to do things of this kind were it safe, but very generous feeding in such disorders is extremely likely to result in disaster, especially to the digestive organs. On the other hand, we must to some extent ignore the standards in the contrary way when we treat somewhat similar conditions that are more prolonged in duration, if it is possible for us to do so. In many of the more chronic diseases this must be done or the emaciation becomes dangerous. Happily, in the more chronic conditions this is usually safe. In tuberculosis, for example, we cannot be satisfied with a normal amount of food, for the tissue destruction incident to the disease itself would then cause continuous emaciation.

We exercise some judgment, therefore, as to the extent to which we follow physiologic principles, particularly when we are dealing with pathologic conditions, just as we exercise judgment with regard to the dose of a drug. At the same time we should no more be safe in entirely disregarding standards concerning foods than we should be in disregarding standard doses for drugs, for there are certain things we cannot overlook without being in danger of doing harm; and it is exceedingly important to remember that the bad effects from erroneous dieting are frequently so slow in appearing and so gradual in their progress that it is impossible in many cases to recognize them by mere clinical observation, particularly when disease has greatly multiplied the complexities that naturally exist. For this reason it is highly important, in all cases in which we clearly depart widely from customary amounts and kinds of food, to have a definite idea as to how near we do come to the quantities that are absolutely needed to preserve a nutritional equilibrium, or we may readily do really grave harm. Those clinicians who still neglect and often scorn dietetic standards and who consider purely clinical observation superior to them not uncommonly do very dangerous things without knowing it. It is easy to discover cases in which

reckoning the value of the food and contrasting it with the standard show that the whole trouble is partial starvation or gross overfeeding. The former is, of course, much more dangerous than the latter if continued for any considerable period, and, unfortunately, it is more common since acute disease gives such frequent opportunity for it through the necessary use of liquid or semiliquid preparations whose ordinarily very limited food-value is but little appreciated, especially in the case of the widely exploited proprietary preparations.

Standards then are chiefly of value to us in saving us from doing harm unconsciously, and in showing us what liberty we may take safely. Of the standards, the minimum requirement is, of course, much easier to determine, and is much the more important. In order to approach these standards more comprehendingly it will be desirable first to devote a brief discussion to the purpose for which foods are used, and particularly to the relative value of the different main types of food.

Purposes and Relative Value of Foods.—Foods are needed to supply the energy demanded for carrying on all the body functions, to furnish material for the building and repairing of tissue, and to provide suitable chemical and physical conditions for the numerous processes that take place within the body. Popularly, and often even scientifically, the name food is applied only to those substances that produce energy or are used in tissue-construction. This is not a just use of the term, for the life of the organism depends ultimately quite as much upon the other substances, and all these, except the oxygen that is inspired with the air, are obtained through the food. We should, therefore, include among foods all those substances that we eat that yield energy, and also those that serve other important purposes in normal circumstances. Some food-substances, such as the various forms of salts, yield no energy; but they are essential, either in tissue-construction or in that they provide proper chemical and physical conditions for the body-processes. It is doubtful, on the other hand, whether any foods are merely energy-producers and not essential in other ways in order to keep the body-processes going in the proper form. It is possible that this is true of fats. Perhaps we could get along entirely without fats if the energy that they ordinarily supply were obtained from an increased quantity of protein and carbohydrate, but it is not certain that we could do this without any resultant harm. The other energy-producers, however,—certainly the protein and probably the carbohydrate,—serve other and highly important physical and chemical ends, in addition to their rôle as energy-producers.

Nevertheless, the process that is most immediately and inevitably connected with the continuance of the life of an organism is the expenditure of energy. This occurs in maintaining the body-temperature; in carrying out all voluntary and involuntary muscular action; in the origination and transmission of all nervous im-

pulses; in respiration, digestion, circulation, metabolism, excretion —in all the minutiæ of the body-processes. A supply of energy is, then, the first consideration in the diet, since without it all functions must stop. Practically all this supply comes from the protein, carbohydrate, and fat. It is important to recognize immediately that the value of these classes of substances in the production of energy is not equal, and that it is not dependent merely upon their bulk or weight, their relative digestibility, or other such factors, but upon the amount of energy that they can be actually shown to yield when they undergo combustion. Their yield in energy is measured in terms of the standard of heat-production; namely, the calorie. Two forms of calories, the small and the great, are spoken of. The smaller is the amount of heat necessary to raise 1 gram (1 c.c.) of water from 0° C. to 1° C., while the great calorie is the amount of heat required to raise 1000 grams (1 liter) of water from 0° C. to 1° C. In dietetic questions the term calorie refers to the great calorie.

When the fuel-value of protein, carbohydrate, and fat is ascertained in an exact manner by determining the actual yield during combustion, it is found that protein and carbohydrate are of about equal value by weight, while fat is of more than twice this value —a fact that is often of extreme importance in dietetics. One gram of dry protein or carbohydrate yields 4.1 calories, while one gram of fat yields 9.3 calories. It is very important to realize, also, that these figures refer to the pure dried substance and not to foods as they are ordinarily seen in nature or as they are prepared for the table. Most foods—particularly most of the protein and carbohydrate foods—contain a very large proportion of water, and often of other substances that have little food-value. This fact emphasizes still further the superior food-value of fatty foods, for these, in contrast to the others, are frequently eaten in extremely concentrated form. Olive oil, for instance, is almost entirely fat, and table-butter contains 80 to 90 per cent. or more of fat; while, on the other hand, bread contains about 60 per cent. of carbohydrate and protein and very little fat; and the lean of beef-steak, only about 20 per cent. of protein and but a small amount of fat. A given weight of olive oil, then, is in food-value equivalent to about four times the same weight of bread and eight or ten times the same weight of the lean of beef-steak. It may easily be seen that all the energy needed could theoretically be readily derived from a comparatively small bulk of fatty food, but practically this is impossible, because digestion and metabolism rebel at too large a proportion, and the required energy must be obtained from a supply of mixed character.

Total Food Demand.—The total value of the food-intake is the point to be considered next. This must be arranged in accordance with the weight of the individual, the amount of work being done at the time, and to a lesser extent it depends upon the sex, the age, and

the relative amount of fat and of lean tissue in the body, and other factors. A standard is determined for an adult of a definite weight, etc., and from this modifications are derived to meet any variations in size, in work done, in body-condition, and in other factors. Emphasis must again be laid upon the fact that these standards are, within certain limitations, flexible; and that the figures cannot be brought within narrow limits. The most acceptable standard for an adult absolutely at rest is an amount of food that yields at least 22 to 25 calories for each kilogram of body-weight. From this, one may readily calculate the total fuel-value of the food needed for persons of different weights. Different amounts are necessary when this adult is at work and when he is at rest. The same person when doing moderate work requires about 35 calories per kilogram; when doing severe work, 40 or more calories per kilogram. The individual person usually considered as a standard of comparison is an adult man weighing about 70 kilos (about 155 pounds). Such a person, when entirely at rest, requires for the ordinary essential functions of his body at least 1500 to 1800 calories per day. When doing moderate work, the demand increases to 2500 or 3000; and when doing heavy labor, to 3500, 4000, or more calories.

Any adult man or woman that weighs less than this standard man would, of course, on account of the smaller amount of tissue, require proportionately less food.

A few other factors likewise need passing discussion, a portion of them being of considerable consequence, others of somewhat minor interest in most cases.

Age has an influence that is of some importance. In advanced age, about sixty years, ordinarily, according to investigations on this point, even though the circumstances remain otherwise the same, it has been determined that the popular belief that less food is required is correct. This is partly due to decreased activity in advanced years, even when the same kind of work is done, partly to the fact that old people often have less tissue, but partly, it seems, to an actual reduction of the activity of the processes that occur in metabolism. In infancy and childhood there is a pronounced difference of the contrary character. Children require many more calories (probably 1½ to 2½ times more) per kilo than do adults. Rubner has especially emphasized the point that this is largely due to the fact that the surface-area of a smaller body is relatively much greater than that of a large body. Hence, the former gives off a disproportionately large amount of heat compared with the latter. Consequently it requires relatively more fuel to replace this heat. The difference is also undoubtedly due in part to the lively and almost ceaseless muscular activity of the infant and young child—an activity that is difficult to measure and is not easily given sufficient credit in matters of this sort. Even when sleeping and hence entirely at rest the demand is, however, much greater than in the adult. The child also requires food in order to construct new tissue; while with

adults growth is past and the requirement is solely for the purposes of maintaining the old tissue and yielding energy.

Sex plays a part in determining the food-demand only in so far as it influences the weight, the severity of the work done, and the amount of fat in the body. In regard to the latter point, women usually have more adipose tissue than men, and require, for this reason, a little less total food, even though other factors are equal. There is, to be sure, a slight influence of sex seen at the time of menstruation; and, of course, pregnancy causes a greater demand. In relation to the woman herself, however, the latter factor is not striking, the increase being chiefly for the maintenance and growth of the fetus; and the effect of menstruation, which is to increase the demand temporarily, is not marked and has no practical significance.

The *influence of the amount of fat* in the body is not seen solely in women, but in all persons, whatever the sex. A fat person, as compared with a lean one, always needs somewhat less food to maintain a balance. Fat protects the body somewhat from loss of heat and from consequent need to make this loss good, but, more important than this, fatty tissue is inactive tissue; hence, with increase of the fat within the body the relative amount of active tissue grows less. Therefore the actual demand, per weight, for energy to supply that exhausted in functionation of tissue grows less. This is one of the chief points to be kept in mind in treating obesity. If a fat man is to become lean, his food-intake must be kept somewhat less than the energy outgo. In accomplishing this it must be remembered that the intake needs to be smaller than the weight would indicate, for his outgo of energy is actually less than that of a person whose weight is the same, but who has a normal amount of fat.

The *atmospheric temperature* has a large influence upon the food-demand, but chiefly in one direction: cold produces a demand for more food because it increases the loss of body-heat—an almost self-evident fact, but one that has been clearly established by investigation. It is, on the other hand, a rather striking fact that elevation of the atmospheric temperature, from a moderate point up to a higher one, does not appreciably lessen the food-demand. The decrease that would be expected as a result of the apparent lessening of the demand for heat seems to be offset by coincident excessive loss of heat due to congestion of the surface, evaporation of sweat, and perhaps other factors. Hot weather, therefore, does not, in itself, as is popularly supposed, lessen the demand for food to any appreciable degree, and in the tropics people need almost as much as they do in temperate regions. Practically, however, this statement concerning the food-demand in very hot weather should not be taken wholly literally; for while there is no marked direct effect of the heat upon the food-requirement, the actual amount required usually does become distinctly lessened if the atmospheric temperature rises from a moderate level to a high one, because all persons then tend to reduce their energy output as far as possible, owing to

the difficulty and discomfort attendant upon active exertion in hot weather.

STARVATION AND OVEREATING

Such are the main factors that influence the total demand for food. The general effect of abnormal reduction in the total supply, —partial or complete starvation,—as well as the effect of an excess, when the demand remains unchanged, may be briefly noted at this point. Starvation, whether partial or complete, of course leads to tissue-loss and ultimately to death. An adult in reasonably robust condition seems to be able, ordinarily, if water is given him, to withstand complete starvation for as long as six weeks. The coincident exclusion of water causes death much earlier; this point will be briefly discussed later. When the food-supply is stopped, the demand for energy does not stop, and the organism is, therefore, driven to obtaining its energy from its own tissues, all tissues containing protein, carbohydrate, or fat being used in varying degree for this purpose. It is possible, to be sure, to meet a deficiency by a proportionate reduction of the expenditure of energy. If, however, this is not done and the demand remains the same, the tissues cannot reduce their expenditure; for it has been repeatedly shown that they are not extravagant in the expenditure of energy, using only the amount that they essentially require, even when very generously supplied. On the other hand, it is possible to decrease, to a considerable extent, the degree of function required of the tissues. Exercise, work, and so on may be reduced to a minimum; artificial warmth may be made partially to take the place of that normally produced in the body, and in this way the demand may be greatly lessened. Indeed, when this is carried to an extreme, the quantity of food absolutely needed is certainly very greatly below that required when a normal moderately active life is led. The very poor often maintain a nutritive balance in this way when their food-supply is far below the normal standard; they work, but their physical and mental productiveness and even their active pleasures are consciously or automatically reduced to a low point. This, simple as it is, is a point of very great importance in the management of a very large group of people who are suffering chiefly from malnutrition. Stuffing them with food is often impossible, and they remain half starved, with a variety of so-called neurasthenic symptoms, until, through more or less complete rest, their demand is so largely reduced that what food they can take suffices to build more tissue.

If, however, the food-intake goes below a certain level, tissue-loss inevitably occurs and ultimately death ensues. On the average, a tissue-loss in an adult of about 50 per cent. of the original total, resulting from starvation, causes death; although this varies widely in accordance with the body condition of the individual, a large amount of fat on the person especially tending to postpone death, for the body-fat is more largely consumed in starvation than

are the other tissues, and, except for this purpose, fat is the least essential tissue. Further, as I have noted, fats have the greatest fuel value, and consequently much fat means a disproportionately large store of fuel in the body. The very young succumb much more readily than do adults; a loss of one-fourth or one-fifth of the body-weight from sudden starvation is likely to cause death in them (Munk).

The figures given above are of direct practical interest as well as theoretic; Senator, some years ago, calculated that a normal adult is likely to die from emaciation in about eight weeks on the diet ordinarily used in acute febrile diseases at the time he discussed the matter. This constitutes sufficient evidence of the necessity for approximate accuracy in ordering a sick-diet, even if for but a short period, for a close approach to starvation, though it be of short duration, may have dangerous results if it is not undertaken knowingly and wisely. The greater susceptibility of young children to the effects of starvation needs to be held in mind in practice more generally than it is.

The effect of excess is seen chiefly and most evidently in the production of obesity. The energy residing in foods that are absorbed from the digestive tract must be either expended or retained. As has been mentioned, in normal circumstances the organism makes use of only the amount that it needs for the immediate demand. If, then, the intake is increased above the demand, the expenditure must be increased at the same time or some will be retained. The expenditure may, of course, be increased by increased work and other normal forms of demand or by pathologic factors; but the point to be noted is that mere increase in the food-intake causes little if any increased expenditure of energy. Rubner has shown that very abundant feeding does cause some increase in the transformation of energy through heat-production, even though the demand is not increased. Some of this is due to the increased demand caused by the added work required of the digestive organs when more food is taken, and not to mere increase in the freedom of expenditure, but some is not. Hence excess in food means retention of energy, and since most of such retention in the body occurs in the form of fat, excess—except under pathologic conditions—produces obesity.

I have dwelt upon this point somewhat for a reason that will soon be apparent in another connection. The fact furnishes, however, one of the cardinal principles in treating obesity. Only seldom is obesity due to a peculiarity in the metabolism of the individual. It is due chiefly to absolute excess in eating or to the relative excess that is due to the individual's expending an abnormally small amount of energy, owing to deficient exercise. The obesity may appear in many instances to be the result of other causes, but careful observation will, in the great majority of cases, show that the foregoing statement holds true.

In addition to producing obesity, excess in food must palpably

tax digestion and all the organs engaged in metabolism, in carrying on the circulation, and in excretion. Self-evident though the last-mentioned fact is, its practical importance in the management of acute and chronic toxic states and of diseases in which the functions mentioned are already overstrained is not often sufficiently appreciated.

The standards that I have given for the total value of energy-intake in the food correspond closely to those that have been pretty generally accepted by authorities for a considerable number of years. Some studies have indicated that a smaller amount might be sufficient; and recently Chittenden, in an admirable and extensive study, has shown the possibility of maintaining apparent good health for as long as several months on a diet containing not only a small amount of protein, but also considerably less total food-value than the standard given. I believe, however, that we should as yet adhere pretty closely to the old standards in dealing with normal persons, and should still use them as guides in the management of the sick. Chittenden's work has accurately demonstrated that a smaller amount may not be evidently and immediately harmful; and various previous determinations of the food-value of the diet of strict vegetarians, and of many persons whose purchasing power for food was low, have shown that these persons live their lives on much smaller energy-equivalents than the standards that I have given. This, however, is not, to my mind, direct evidence that we should set our standards at a lower point. It is, at most, merely a determination of the lowest point that is free from evident and immediate danger. I remain largely influenced by the belief that the *average* food-intake of a large number of normal persons—a food-intake that is determined, for the most part, by the appetite—is a fairly close indicator of the *average* normal man's wants. Such a man certainly takes a quantity of food that approaches much more closely to the standards that I have followed than to lower ones. There is a ready tendency to state that a man that can do so eats too much. It is beyond question that a very considerable proportion of those that are in easy circumstances take an excess of food, but I do not believe that the great majority of such persons take a considerable excess; and food-standards have by no means been drawn solely from studies of persons in easy circumstances. Unquestionably, Chittenden's work has shown that a man that is not in want usually eats more than is necessary to keep him from immediate emaciation and loss of vigor, but I do not believe that the extreme low limit of immediate safety should be considered the ideal to be striven for.

Among the several reasons to be urged in support of this view, one, to my mind, is sufficient: we are supplied with tissues and with functional power in every detail of the body-structure far beyond the amount necessary to maintain life with all the apparent evidences of good health; that is, as Meltzer terms it, there is an extensive "factor of safety" in all our functions. We should be

quite as well justified in holding that we should be better off were the bulk of the liver reduced to the lowest point compatible with apparent health, or were the number and depth of the respirations decreased as much as could comfortably be done, as we should be in making a similar requirement for the food-intake. Furthermore, while every one will admit that the appetite is not a good indicator of the needs of every individual, it is not correct to state, as is often done, that this is a wholly unscientific method of determining the needs of the average person. There are good reasons for the statement that, while imperfect, it is one of our best means of determining an average standard. I have referred to the fact that any considerable excess of food leads to the formation of excessive tissue, chiefly fat. That is, if one takes an amount of food that is very appreciably above the quantity required, there results a gradually increasing obesity. When one considers, in connection with this point, the remarkable fact that most normal persons follow their appetites in determining their food-intake, and yet that most of them do not grow obese, but maintain a weight that varies but little throughout many years, I think that one is driven to the conclusion that most persons, in following their appetites, eat an amount that, in the end, fairly closely approximates their requirements.

And a more important point should be remembered: While a certain number of persons appear to maintain good health on less than one would, from the standards reached in the way that I have followed, consider necessary, a broader important fact has also been pretty clearly demonstrated, and is generally accepted by physicians and sociologists. Those that take a smaller amount, not because they will, but "because of the bitter 'must,'" furnish an unduly large proportion of the ill-developed and inefficient, who are weak and non-resistant to disease. Yet, as a rule, such persons do not, of course, regularly lose appreciable amounts of tissue, or their lives would be of short duration. In other words, they appear to reduce their demands to a low point that is compatible with a nutritive balance, but is, ultimately, even though not at once, associated with poor development and poor resistance. This fact, which has, I think, been demonstrated with sufficient accuracy, is a very weighty argument against setting standards of food-intake much below the old standards, even though individuals have in some instances been shown not to have suffered from smaller amounts during the time that they were under observation.

This rather controversial manner of discussing the question last under consideration has seemed somewhat necessary because the studies of a number of authors—most particularly, the investigations of Professor Chittenden—have recently set up a strong tendency to exercise measures in regard to the diet of the well that are, I believe, erroneous, and likely to prove at times very harmful. Indeed, I am quite convinced that I have already seen decided harm result in repeated instances from following this dietary propaganda.

They also lead to conclusions concerning the diet of the sick that, while salutary in many instances, would be highly dangerous in many others. As I have indicated, I do not think that we can wisely urge normal persons *in general* to reduce their diet to any noteworthy extent below the amount that they normally take. This point must certainly be determined according to the circumstances of the individual. With those that are out of health also it is a matter to which especial attention must be given in each case, and it should not be decided according to any routine practice. The amount cannot wisely be reduced in any instance, unless one determines, by accurate inquiry into a person's habits of eating, of work, etc., that he takes an excess, and this means, I think, an excess above the standards that I have given; or, unless the patient presents obesity or some other palpable evidence of the results of overfeeding, or is the subject of certain diseases in which there are special indications for reduction of the diet.

Often in hepatic or renal disease, or in other conditions in which the labor of metabolism and excretion is but poorly performed, moderate restriction is important, and sometimes severe restriction is necessary for a short time, though it is rarely wise to carry out the latter for any considerable period. If a patient has digestive disturbance and detailed inquiry determines that he eats very freely, the rest afforded his digestion by a moderate and not very prolonged reduction of his food is likely to be an essential factor in reëstablishing his health; but this is not a general principle in dieting those with digestive disorders, for in very many instances the contrary measure is necessary, and health is regained only through more abundant use of suitable food; and I may say decidedly that in cases of this sort the food is very often reduced too much or for too long a period, with consequent bad results upon general nutrition. Even in obesity one at times finds it unnecessary or impossible to reduce the food greatly, and is obliged to make use of other measures that are more important in such cases, these measures being, as a rule, chiefly directed toward increasing the expenditure of energy; for instance, by increasing the exercise.

In some conditions the demand for energy is less than normal, though this is relatively unimportant. In such instances the food-intake may be decreased below the normal standard. In old age, as was noted, this is the case; and some diseases—for instance, myxedema—show a pathologic reduction in the activity of metabolism. In early life, on the contrary, there is a much greater demand than the standards given would indicate; and in some diseases there is abnormal activity of metabolism, and consequently an increased demand for food. In exophthalmic goiter, for example, the organism may consume more than double the amount of food that a normal person would eat, and expend all this energy, and, therefore, need it all. In many other diseases also—particularly in some chronic infections, such as tuberculosis—there is a more or less marked

destruction of tissue, due to the toxemia, and this constant loss of tissue can, as a rule, be checked only by taking an amount of food greater than that which is normally essential. In a further class of persons,—and this class is extremely large,—owing to abnormal fear of taking sufficient food, to poor appetite from various causes, to nervous overstrain, or to various other factors in unhygienic lives, the food-intake is consciously or unconsciously made so low that the deficiency in food is the main factor in causing more or less severe and protracted ill health. These cases are exceedingly numerous, and they are extremely likely to be called neurasthenics; or very often some relatively minor actual disorder that is discovered is erroneously thought to be the chief thing at fault. There are hosts of people whose essential treatment consists simply in increasing the food to an amount about equivalent to the normal standard, or sometimes somewhat more than this.

Let us now consider in a summary manner how largely we ought to use this knowledge of total food demands in practice, that is, attempt to determine accurately what calorific value we are giving, and make it approach the standard. The precise determination of the calorific equivalent of a general mixed diet containing many food substances is extremely laborious, and it is also impossible to carry it out with even approximate exactness without weighing or very accurately measuring the food articles and then computing the value of each of them. Clearly, this is impracticable—indeed, impossible—in a great majority of walking cases. We must then content ourselves in most such cases with pointing out those things that may be taken and those that must be excluded, and then depend chiefly upon the patient's appetite to secure sufficient amount, always, however, indicating clearly to him the kind of foods that he is to eat especially freely or sparingly, in accordance with our desire to have him gain or lose or remain stationary in weight. But even in such cases we have a means, and a reasonably accurate one, of determining, by continued observation, whether the end desired is being attained as regards general nutrition, that is, by frequent weighing we determine the effect of the diet and we modify our orders accordingly. It is exceedingly important that this be done regularly. Probably the commonest error in dieting is to reduce general nutrition unwittingly and without desiring to do so, often, indeed, with the desire to do the contrary. The restriction that goes with nearly every diet is in many cases extremely likely to lead to emaciation, and thus to do as much damage to general health as the diet does good to the disorder especially under treatment, unless the effect on the weight is carefully watched. Less common, but often of importance, nevertheless, is an obesity of some degree that is produced by too generous overfeeding without watching the weight. Either of these can usually be entirely avoided by the aid of the scales.

But in cases that must be subjected to more severe restrictions, and most especially in those that are on a very narrowly limited

diet that differs greatly from the normal, we cannot depend upon the appetite to secure enough for the patient's needs, we frequently cannot weigh the patient, and the disease itself, indeed, often causes so much derangement that the weight would not determine for us whether or not the food was insufficient. Such cases are especially those of acute disease that are frequently on a liquid or semiliquid diet, with which there is special danger of serious undernourishment. In many cases also of diabetes and obesity, and in some other conditions, we run grave risk of damaging the patient seriously or of not accomplishing our ends unless we determine definitely what our diet is worth. This can be extremely easily done in the most important conditions,—in severe acute disease,—for in these conditions the diet is nearly always so simple and the value of the food-stuffs is so well worked out that we can carry the value of the total day's diet in our heads. If it were a general practice to calculate the value of the diet in such cases, we should soon be rid of the very common custom of using a lot of liquid and semiliquid foods, mostly proprietary, in the treatment of those who are very sick, without any real knowledge of their actual worth as foods, and merely on the basis of loose clinical impressions as to their value. A large number of deaths have almost certainly been caused, or at least hastened, by such methods.

Another way in which a dietary standard is very helpful is in determining whether we are or are not overdoing the matter in cases which we wish to feed very generously. We often find delicate persons who have been urged to eat very freely, taking an amount of food which, when calculated approximately in calories, proves to be more than sufficient to nourish a man doing very hard labor. It is extremely difficult oftentimes to appreciate that this is being done unless we work out the figures in calories and contrast them with the standard. The danger in such gross overfeeding is, of course, chiefly the strain upon the digestion, to a lesser but often important extent upon other functions. It not infrequently results in actual digestive breakdown, or it causes so much continuous strain upon digestion and metabolism that we frequently see the paradox of a person being extremely generously fed, but losing weight, or at any rate not gaining—simply because he is overdoing the matter.

SPECIAL CLASSES OF FOODS AND THE DEMAND FOR EACH OF THEM

Some consideration of the needs of the organism in various normal circumstances for the special classes of foods is next necessary, since some of the most important principles of dietetics fall under this heading. In this connection both the energy-producing capacity and the other qualities of foods must be referred to. As I shall note later, it is necessary to remember again in this connection that we use the standards not as laws, but as guides, but there are certain ways in which they are very important.

The energy necessary for the organism is derived, practically speaking, solely from protein, fat, and carbohydrate, though in small amounts from the less complex substances derived from these, and in slight degree from other substances. Theoretically, any one of the three classes of foods mentioned might be thought to be able to furnish all the necessary energy if used in sufficient amount. Practically, however, it is essential to have both protein and carbohydrate, or grave disorders of metabolism will occur, and it is best to have a mixture of the three, since in this way a greater variety of food articles becomes available, and it is easier to maintain general nutrition, too, and the various body functions, particularly digestion, suffer the least strain. In this way nutrition can be most easily and certainly maintained in proper condition.

The amounts of these substances that are suitable for normal persons vary within wider limits than does the proper amount of total food. With diseased persons it is often necessary, for a longer or shorter time, and occasionally even permanently, to reduce the quantity of one or more of them very greatly. It must be remembered, however, that this is always an undesirable sacrifice of normal conditions, and there are limits to the degree and the duration of this reduction if bad results are to be avoided; and if one food is reduced, the others must, if possible, be increased in amounts sufficient to maintain the proper fuel-value of the total food. If the latter point is neglected or cannot be carried out, tissue-loss will inevitably occur. Of course, it sometimes cannot be done, particularly in acute diseases; but in such cases the plan of diet is necessarily temporary, and emaciation of some degree is then necessarily permitted to occur while the plan is in use.

PROTEIN FOODS

Of all foods, the most immediately essential are the nitrogenous, for the actively functionating tissues are nitrogenous. In the functionation of these tissues some loss occurs, and this loss must be made good. This is accomplished through the use of nitrogenous food, and such food must be largely of a character similar to the nitrogenous substances found in the body-tissues—it must, namely, be protein.

The term protein includes albumin and globulin of various kinds, represented by egg-albumen, muscle protoplasm, the albumin and globulin of blood, and vegetable albumins; nucleo-albumin, represented most strikingly by casein; and nucleoproteid, which, as its name implies, is the chief nitrogenous substance in nuclei, and is found in large amounts in animal tissues containing a relatively large bulk of nuclei, in the seeds of vegetables, and, in smaller amount, in all other animal organs and in other vegetables.

Protein also includes the gelatinous substances, represented among

foods chiefly by gelatin; but gelatin needs to be distinguished from those mentioned above. While the latter are both energy-producers and tissue-builders, gelatin is solely or almost solely an energy-producer. It is not certain whether gelatin can serve at all to produce tissue. At best, it is unquestionably less efficient for this purpose than the others, and it should be used chiefly for the purpose of increasing the energy-value of the food. If some of the other forms of protein, or even the ultimate digestion-products of protein (amino-acids), are given with it, gelatin may then serve indirectly in the building of tissue; for it is consumed to yield the necessary energy, and thereby spares some of the other protein which would otherwise be burned as fuel. This permits of the use of the other protein for tissue-construction. Possibly it may help in directly building tissue. Gelatin is, at any rate, valuable as an auxiliary food, but it is certainly not sufficient as the sole nitrogenous food. Its nitrogenous character is, of itself, of comparatively little practical importance in its use as a food.

In addition to gelatin and the other protein substances extractives containing nitrogen—creatin, creatinin, and the like—are found in many foods, particularly meats. They make up a large part of the nitrogenous element of meat-soups and meat-extracts. These substances have a low theoretic fuel-value, and some of them actually yield a small amount of energy in the organism. There is, however, no question that the value of those extractives found in foods, as energy-producers, is very small; and they are almost certainly of no consequence as tissue-builders. They are of use in the diet, since they stimulate the appetite and gastric secretion, they to some extent control hunger, they are believed also to have a stimulating effect upon the nervous system and the circulation, and they may have other as yet unknown uses. Nevertheless they are essentially not actual foods in any way that we now know.

Protein is contained in animal foods of all sorts in somewhat varying amounts—in large quantities, except when the food article is chiefly fat. Meat of different kinds as it appears on the table contains, roughly speaking, 18 to 25 per cent. of protein; fish contains a little smaller amount; eggs, about 13 per cent.; and milk, about 3.5 per cent. The leguminous vegetables, when dried, contain 20 per cent. or more; and all the other members of the vegetable kingdom contain it in varying but smaller amounts—dry rye and oats, 12 to 14 per cent.; wheat, 7 or 8 per cent.; rice, 7 per cent.; many other highly starchy foods, such as potatoes, very small quantities when in their natural state or when cooked without being dried.

Animal and Vegetable Protein.—Animal and vegetable protein is apparently, from exact studies of this point, of about equal value in preventing tissue-loss or in building tissue. It is possible to obtain the requisite amount of protein from either animal or vegetable sources or from a combination of the two, provided digestion permits of this. Some human beings obtain all their protein from vegetables,

and many animals do this also; but for the human being such a custom certainly produces an unnecessary strain upon digestion. The bulk taken is unduly large, the proportion of carbohydrate is unduly excessive, and a large amount of indigestible material, chiefly cellulose, is ingested at the same time. The latter burdens the digestive organs unnecessarily, and furthermore the cellulose in large part incloses the nutritive carbohydrate, the protein, and any fat present. This makes it very difficult for the digestive juices to reach these latter substances and carry out their digestion properly. In animal foods, on the contrary, the protein is present, for the most part, either in relatively concentrated or in relatively digestible form—usually both.

So far, there ore, as our present knowledge goes, we are justified, from the standpoint of metabolism, in considering animal and vegetable protein as being of about equal value, both being assimilated, so far as can be determined, in the same way. The desirable amount of protein is, however, by normal custom, secured from both animal and vegetable sources because this is best for the digestive organs, and because vegetable foods are needed for other purposes. As a rule, it is considered that about one-third should be from animal sources. With the sick, the choice as to the amount of animal or vegetable protein is made largely in accordance with the state of digestion. If the case permits of it, both should be used. Some animal protein keeps the labor of the digestive organs within bounds because the animal protein is usually digested readily. It is, at the same time, always desirable that some vegetable protein should be used. One coincidentally secures in this way much of the necessary carbohydrate and also a judicious variety of food; and the use of vegetable food likewise insures the ingestion of a certain amount of cellulose and of other material that is poorly digested, and while a very large amount of this material is harmful, some of it is necessary in order to keep the bowels moving normally. Various diseases cause one to vary one's choice between animal and vegetable protein. Some further details in regard to this point will be noted later in considering the carbohydrates and in referring to the general features of the diet in various groups of diseases.

The Amount of Protein Demanded by the Organism.—The amount of protein needed has been the subject of an enormous amount of discussion and experiment, especially within recent years, and the question is still far from settled. Indeed, I do not believe that we shall ever be able to state the necessary amount within narrow limits. A small amount is indisputably known to be needed, but if the necessary supply of energy is kept sufficiently high by the generous use of other foods, especially carbohydrates, the organism can maintain a nitrogen-equilibrium with a very small amount of protein food. Chittenden has recently shown that an extremely low protein diet may be continued for months without evident harm. On the other hand, it is known that very large amounts may be taken

for an equal or greater length of time, without appreciable damage. There is, however, a well-grounded and reasonable general opinion that very large amounts of protein cause some unnecessary strain upon digestion, and that they tax the liver and other organs chiefly concerned in the metabolism of the protein, and also the circulatory organs and kidneys, which carry on the transportation and excretion of the end-products of protein metabolism. Furthermore, there is some ground for believing that very free and prolonged indulgence in protein tends to produce gout and various ill-defined disturbances of metabolism. There is, therefore, good reason for moderation in using protein.

On the other hand, a certain quantity of protein must be used, and it has generally been considered by investigators that this quantity is fairly large. The figures that have been most generally accepted for a long time—those of Voit—demand about 118 grams daily for the average man of 70 kilos weight, the amount being slightly increased or decreased in accordance with increase or decrease in muscular work, though work is of little moment in this particular as compared with its great importance in relation to the question of the total food-demand. Those weighing more or less would then require a slight, but only a slight, increase or decrease in the amount.

These figures are undoubtedly generous, and perhaps excessive. Chittenden insists that it is possible to maintain a nitrogen-balance on even one-third of this amount, and that it is advantageous to take only one-third, or at most one-half. He recommends this because it reduces the work in the metabolism of protein and in the excretion of the end-products of its metabolism, and yet maintains an equilibrium between the intake and the outgo. From a purely theoretic standpoint, however, I feel that this extreme view cannot be strongly urged; and from the practical standpoint it would be difficult, and particularly with the sick often impossible, to follow it successfully. The statement that I have made in relation to the total food-demand may be applied here again. The lowest possible limit that can safely be adopted is not the ideal standard, and is not the wisest one, if we are to judge from the manner in which nature provides in other ways. Observation also of those persons who from necessity take very small amounts of food throughout their lives appears to show clearly that they are, on the average, ill-developed and poor producers, and that they have poor resistance to disease; and, with these people, it has been shown that the protein intake is nearly always more seriously reduced than that of the carbohydrates and the fats.

The only real advantage urged for a very low protein diet with a normal person is the reduction that it effects in the strain upon metabolism and excretion. Normal organisms are, however, planned by nature to carry out not only the minimal amount of work that can safely be arranged for them, but more than this; and, so far as we can determine, not only can they do more than this minimal amount

without any harm, but their powers of work often actually suffer unless more than the minimum is required. Muscular, circulatory, and respiratory power, for example, do not reach their greatest efficiency through a careful limitation of the demands made of them to the lowest point that is compatible with their performing what is actually essential; and life is not prolonged, but certainly is usually shortened, by so limiting their labors. With digestion also it has been well determined that while severe demands are harmful, a careful provision of bland foods, when this is long continued, may seriously impair digestive capacity and do quite as much harm as would an excess. Indeed, it has been most strikingly shown at some of our Agricultural Experiment Stations that such a course with cattle may even produce death, although the cattle ingest and absorb enormous quantities of bland forms of food.

We can, I think, consider it demonstrated that the proper course with all functions is not to push them to the upper safe limit of their capacity, and also not to reduce their labors to the lowermost point of safety. A mean between these two must be chosen, and I see no better way of determining this mean than the somewhat empirical one of observing what a large mass of people do with apparent safety and with the best results. I think that observation of persons whose protein intake is known to have been continuously, throughout many years, as little as half Voit's standard shows that a large proportion of such persons are below the average in general productiveness, and, apparently, in resistance to disease.

A moderate restriction of protein is necessary with the very poor, because it reduces the cost of food somewhat—since protein is, as a rule, the most expensive form of food—and it is, perhaps, indicated with the well-to-do as a somewhat general custom because it helps to keep within moderate bounds the tax on metabolism and excretion, for, so far as we now know, protein and the end-products of its metabolism are likely to cause a greater tax upon these functions when used in very large amounts than do fats and carbohydrates when they are used in excess; therefore the protein needs to be limited a little more carefully. It is known that substances that are more or less toxic are formed in the metabolism of protein; that practically all the end-products of nitrogenous foods are excreted through the kidneys; and that these end-products, therefore, cause the kidneys to labor harder than do the other forms of food, since the end-products of fats and carbohydrates are largely excreted through the respiratory organs. With ordinary protein foods, however, the amount of irritating substances excreted is small, and the great mass of the end-products consists of urea, which has no noteworthy toxic or irritating qualities. Some of the substances that are formed and excreted are deleterious in large amounts, but there is no evidence that they cause more than normal and proper functionation of metabolic and excretory organs where present in the usual amounts. In considering the ill effects of foods we must remember that the pos-

sible harm is not all on the side of protein, and that a middle course must be held. If the protein is much reduced, the carbohydrates and fats must be coincidentally increased or the food-supply will fall below the demand; and generous use of fats and carbohydrates is not free from ill effects upon metabolism, and is still less free from damaging influences upon digestion. Large amounts of fats may certainly produce very serious intoxication if the amount of carbohydrate is not kept at a fair level; and this intoxication is much more grave than any that is known to be due to large amounts of protein. Actual intoxication occurs, of course, only when dietetic conditions are extremely abnormal, but even with a normal diet some toxic and irritating products of fats are produced in metabolism, and a large part of these must be excreted through the kidneys. Further, the powers of many persons to assimilate carbohydrates are limited, and it is probable that there is some danger to metabolism in a very free use of carbohydrates. It is possible that excess in the use of carbohydrates may cause diabetes, and it is certain that those of so-called gouty diathesis, or who have a gouty heredity, are not infrequently more damaged by even moderately free use of carbohydrates than they are by moderate amounts of protein. From the standpoint of digestion, except in special cases, moderation in the use of fats and carbohydrates is certainly more commonly desirable than limitation of the use of protein, for the latter is, as a rule, more easily and more completely digested than the others, and both carbohydrates and fats frequently cause digestive disturbance.

The exact figures for the normal amount of protein cannot, as I have said, be dogmatically given; but we can approximate with reasonable closeness. I feel that the dangers from great stringency are quite as real and important as are those from moderate generosity. The figures given by Voit seem, therefore, to be not far from the proper standard, though they are, perhaps, unnecessarily generous, and 100 grams daily for an average man doing moderate work would probably be sufficient. There is no real evidence that those that take at least 75 grams daily show any actual ill-effects as the result of deficiency; but I think that this may reasonably be made the lowermost wise limit for a normal man. The protein, as a rule, with those that can choose with some freedom, constitutes in the neighborhood of one-sixth of the value of the total food. The figures that I have given would reduce it somewhat below this point. As I have stated, however, all figures are reached somewhat arbitrarily, and probably no harm could result from such a reduction if the carbohydrates and fats were so chosen as to make up the proper total.

This question has been discussed at some length because of its importance in relation to dietetics in general, and particularly in relation to the dietetics of the sick. If normal persons take too much protein, most sick persons certainly do; for they, as a rule, have greater difficulty in metabolism and excretion than the well. As I have indicated, however, I feel that the view that people in general

eat too much protein is not tenable. With the sick, this question, like that of the total food-supply, must be settled in accordance with individual conditions and the general purposes in view. Persons that are found to eat very large amounts of protein, whether they are sick or well, accomplish no good results thereby unless they have to do this on account of difficulty in taking other foods freely. In the absence of such a reason the practice should, on general principles, be stopped. This practice is unquestionably very common among the well-to-do. Some digestive disorders are largely dependent upon the excessive use of protein, and in such cases the trouble may often be relieved by checking this excess; but in other disturbances of digestion—and such instances are many—the protein may have to be relatively or absolutely increased above the normal standards, for other foods are more likely to disagree and nutrition must be maintained by using an excess of protein.

There is a large and very important field for the restriction of protein in treating certain disorders of metabolism. These are chiefly diseases of the liver, arteriosclerosis, gout, and those indefinite disturbances of health that are usually termed gouty or lithemic conditions, but that are undoubtedly due to varied and, as yet, largely unknown causes. Clinical experience seems to demonstrate pretty clearly the utility of a reduction of the animal food in many such cases, and there are some known facts that may explain its effect.

In the first place, taking large amounts of vegetables in place of animal foods usually reduces the protein-intake, whether this is intended or not, because it would require an uncomfortably large bulk of most vegetables to make up a generous protein-ration. In addition—and this is probably very important—it decreases the amount of nitrogenous extractives in the diet, and it leads to a lesser use of condiments and sauces. It is also possible that the increased intake of vegetable salts of various forms that is always associated with a largely vegetable diet may often have a good effect. Finally, the kinds of food that form uric acid and xanthin-bases are also reduced by this measure. While the latter fact has by no means the overwhelming importance that has often been attributed to it, it must, for the present, be counted as worthy of somewhat serious attention, for if no other good purpose is served, it lessens the labors of excretion, since uric acid and its congeners are relatively difficult to eliminate.

It is not wise, however, to make reduction of the animal foods a routine practice in any of the above-mentioned diseases, particularly in the ill-defined disturbances of metabolism. Persons with any of these disorders often take too little protein, animal or vegetable, either voluntarily or as the result of professional advice. I have many times, in so-called lithemics, found the urinary nitrogen only half the normal amount or less, which furnished very clear evidence that the protein-intake of these patients was very low; and treat-

ment which includes increase of the protein is often more successful in such cases than that which does not. If observation of the diet of such persons shows that the protein-ration is small, they are often actually in need of more protein, and improve when it is given.

But if the liver or kidneys are already diseased and have a hard struggle to do a normal amount of work, or even less than a normal amount, the protein-intake should very commonly be kept as low as is possible without causing tissue-loss, and temporarily it may often be wisely reduced much below this point. On the other hand, in many conditions associated with malnutrition, of which the most common example is tuberculosis, the absolutely essential point in the diet is usually to insure a large food-intake by providing food that is acceptable to the palate and the digestion. In such cases protein must ordinarily be used in excess, because its bulk is small as compared with that of most carbohydrate foods, and it is, with most persons, much more palatable and more easily digested in large amounts than are most fats and carbohydrates. Furthermore, an important point in this connection is that protein yields its energy in the course of normal metabolism most easily and most quickly of the three main classes of foods, for the organism normally makes use of all the protein ingested first of all—and, indeed, almost at once; while of the fats and carbohydrates only that portion necessary to supply the remainder of the food-demand is used immediately, the rest being stored.

In this last class of cases, then, the purpose is to increase the supply beyond the outgo, and one must follow this purpose, as a rule, even though it involves using an excess of food, or one loses the fight; and an excess of food is likely to mean a special excess of protein. The danger from a moderate excess of any form of food is remote as compared with the effect of continued tissue-loss, provided one is careful not to use a greater excess of any of the foods than is necessary to secure a moderate and gradual increase of tissue.

There are one or two further general physiologic points that need to be mentioned in relation with the protein-demand of the organism. There is a wide-spread belief that meats and other protein foods increase the muscular tissue, and that large amounts of them are necessary also in feeding those that need to perform much muscular work. With a young and growing organism, an abundance of protein food—even a greater amount than that which is evidently used directly in building tissue and in repairing waste—is necessary, in order to produce good muscular development. The results of some experimental work in young cattle have most forcibly shown the truth of this point. In convalescence from disease, also, free feeding of protein is desirable, for at such times the organism retains large amounts of protein for reconstructing tissue, and it is probable that an especial abundance of protein favors this, as it appears to do in the child. It is probable, too, as Friedrich Müller suggests, that an abundance at this period may even cause the reconstructing

process to improve upon the previous tissue and to increase its bulk, in case it has been insufficient, and thus to make the patient better developed after the disease than before.

In adults with normal health, however, exact experimental work shows that feeding protein freely does not increase the muscular tissue unless the patient is very decidedly overfed in total quantity of food, and while under such circumstances nitrogen is retained, it is uncertain what becomes of it, and it is wholly unproved that it goes to the formation of muscular tissue. Increased function does increase the bulk of the muscles of the body, but increased protein food certainly does not do this readily or to a large extent, if at all. In healthy adults using a normal amount of food only the amount of protein necessary to replace the loss from wear and tear is used in tissue-building, the remainder being immediately broken down, its energy used, and its end-products excreted. Protein food has likewise no especial value in relation with hard muscular work beyond its value as an energy-producer. Muscular work makes a demand merely for energy and not especially for nitrogenous material. The protein needs to be increased slightly when hard work is performed; but this increase is small and is apparently intended merely to replace the extra tissue-wear. More than this is not necessary, for fats, and especially carbohydrates, can provide the extra amount of energy quite as well as protein.

There is also a wide-spread view that protein should be used in very limited quantities in hot weather. The lay reason commonly given for this is that "meats make one hot." The principle of using smaller amounts is probably correct, because, owing to the depressing influence of very high temperatures, functions in general are carried out with much more difficulty; and on account of the abstraction of water in free sweating excretion through the kidneys is more difficult to perform unless water is taken with great freedom. Hence it is harder for metabolism and excretion to deal with protein in hot weather. The common statement, however, that protein is a heating food seems true, to some extent. Rubner has found that extremely large amounts of protein do increase the production of heat to a considerable extent, and Magnus-Levy got even more striking results.

Characters of Various Kinds of Animal Protein Foods.—A question that often arises is that relating to the relative wholesomeness of light and red meats. Recent studies have shown that the very prevalent opinion that the latter contain more extractives than the former is erroneous. Consequently, there is no peculiar objection to giving red meats in conditions in which extractives are to be avoided; that is, in gastric hypersecretion, in nephritis, and in some other conditions. Extractives should be avoided in nephritis because they merely require to be excreted, and, practically speaking, furnish no energy and build no tissue; and hence, in diseases of the kidneys, and often in diseases of the liver and other disorders in which

excretion is carried out with difficulty, large amounts of animal soups or broths and other preparations that contain a relatively large proportion of nitrogenous extractives are contraindicated. In gastric hypersecretion they are contraindicated because they normally excite secretion.

As was stated, however, the question as to the kind of meats to be used is not usually one relating to the amount of extractives in the meat. The kind of meat recommended is decided largely by a knowledge of the denseness of the fiber, especially when the meat is cooked, by the amount of fat that it contains, and by the quantity of nucleoprotein in it. As a rule, the meat from young animals is more tender than that from older animals, although there are occasional exceptions to this. One supposed exception that many of the laity will cite at once is veal, which generally ranks as much less digestible than beef. This is very largely a misconception, based upon the imperfect methods of killing, keeping, and cooking veal that are usually found in this country—the cooking, in especial, being very often unwholesome. A roast of good veal, well cooked, is very digestible.

There are marked differences in the fiber of the meats from different species of animals, however; good beef, chicken, and, to a lesser degree, lamb and mutton are tender and readily digested, while pork, for example, is well known to be harder to digest, largely because of its dense fiber. This hardness of fiber is very conspicuous also with some of the coarser forms of fish. Some shell-fish—crabs, lobsters—have a rather general evil reputation, partly owing to the fiber of their flesh and partly as a result of disturbing substances that they are popularly supposed to contain. As a rule, however, they are in themselves nutritious, and are fairly digestible, provided they are not, as is so commonly the case, served in unwholesome form. The harm that they do results chiefly from the manner of serving, and from the fact that unless carefully kept they readily undergo bacterial changes. Oysters properly enjoy the reputation of being, in most cases, suitable for even delicate digestions, if the dense muscular portion is removed, while clams are tougher and are less useful, except for making broth.

The effect of the amount of fat in meats is often important. The fuel-value of any meat is in almost direct proportion to the amount of fat contained in it, but the digestibility is frequently in inverse proportion to the amount of fat. This is another reason, and a most important one, why most pork ranks as indigestible, although some cuts, particularly bacon, may readily be prepared so as largely or completely to overcome this. The fat-content also largely influences the digestibility of many forms of fish. This is particularly attributable, in this instance, to the fact that the fat is so closely intermingled with the lean that it cannot be readily separated and discarded. Fish, such as salmon, Spanish mackerel, shad, butter-fish, eels, and lake-trout are, as a rule, relatively fat; for this reason most of them

are likely to disagree if the digestive tract takes fat poorly. It should be remembered, however, that the amount of fat in fish as it is eaten is often chiefly dependent upon the manner of cooking and serving. The dark meat of fish and fowl contains a larger percentage of fat, intimately intermingled with the lean, than does the light meat; it is, therefore, as a rule, more difficult to digest.

The quantity of nucleoprotein in meats is, as I have noted, largely dependent upon the relative proportion of nuclear material in the meat. Most of the internal organs—pancreas and thymus (sweetbreads), liver, and kidneys—contain a comparatively large amount; muscles, less, but still a noteworthy amount. Oysters contain a good deal on account of their relatively large livers. Protein foods containing much nucleoprotein usually agree very well with the digestive organs, if the latter are not already decidedly disturbed, and if these foods are properly prepared for the table. They yield, however, large amounts of purin-bodies—uric acid and xanthin-bases—as end-products, and these are almost certainly difficult for the kidneys to excrete, and probably are relatively difficult for the organs of metabolism to deal with. It is well, therefore, to limit them somewhat closely in diseases of the kidney, in derangements of the liver, in cardiovascular diseases, as well as in gout and other indefinitely located disorders of metabolism.

The Effect of Protein Foods on Digestion

This differs in accordance with the character of the protein. All protein demands hydrochloric acid for its gastric digestion, and all protein combines with hydrochloric acid. Therefore it is often said in a general way that protein is well digested when the gastric secretion is normal or hyperacid, and that it causes improvement of symptoms in the latter cases, whereas it is digested with difficulty when the gastric secretion is reduced. This is a poor statement of the case, however, for, as a matter of fact, with reduced or absent gastric secretion protein is commonly well digested by the pancreatic and intestinal secretions, except in the comparatively rare cases in which these latter secretions also are seriously reduced. In hyperacidity, on the other hand, the end-effect depends largely upon the character of the protein. The extractive substances in meats and in broths, soups, etc., made from meats tend in normal persons to increase the gastric secretion, and they frequently make a hypersecretion worse even though the protein contained in these foods saturates some of the acid. On the other hand, the proteins that are of relatively flat taste and contain very little extractives call forth of themselves extremely little gastric secretion, and still serve to saturate the acid that is secreted, hence they are usually well borne in hyperacid cases, and serve frequently to quiet the symptoms. The latter is true ordinarily of the protein of milk and eggs, and apparently of most vegetable protein. The question whether

protein is well digested by the pancreatic and intestinal secretions is best determined by an examination of the stools and by determining the amount of intestinal decomposition products in the urine.

CARBOHYDRATE

Carbohydrates stand next in importance to protein among the foods, for they are energy-producers, and are also known to be important in other ways, which are as yet of rather obscure nature, in carrying on the body-chemistry properly. The latter point may be briefly mentioned first.

The only way in which carbohydrates are known to be essential to the body-chemistry is in relation to the metabolism of fats, but this is of much importance. Largely through studies of diabetes it has been shown that a diet composed almost exclusively or solely of fats and protein results in the condition termed acid intoxication, in which large amounts of β-oxybutyric acid and its derivatives, diacetic acid and acetone, are formed and are imperfectly oxidized. The presence of the acid results in the abstraction of alkalis from the body-fluids and tissues; and besides this, the acid almost certainly forms combinations with the protein tissues. The result is disturbed health and, at times, severe symptoms, which are usually referable chiefly to the nervous system, though the gastro-intestinal tract, the kidneys, and probably most other tissues also suffer. If the poisoning is extremely marked, death may occur—as often happens from this cause in diabetes and occasionally in other conditions.

The acids are produced largely, and perhaps entirely, from the fats. They appear normally in small amounts, but under abnormal conditions—chiefly abnormal conditions of diet—the amount formed is excessive and the acids are not properly oxidized to harmless substances. For some reason, however, if considerable amounts of carbohydrates are taken, the acids do not usually appear, or, if already present, they disappear more or less completely. It is considered by some authors that this is due simply to the fact that the carbohydrates spare the body fats from being consumed and make less food-fat necessary; namely, that the condition is due solely to the fats and that the carbohydrates simply eliminate the consumption of more or less of the fats and thus eliminate their effects. This point of view has some evidence in its favor, but it is probable that the carbohydrate has more direct effects in preventing the acidosis. At any rate, the intoxication is, in a large proportion of cases, brought on chiefly by the absence or reduction of carbohydrates, and it is often controlled by adding these to the diet. From 80 to 100 grams daily seems to be the lowest safe limit of carbohydrates in avoiding this condition, but probably 150 grams is, in most circumstances, a better minimal amount.

This condition develops most frequently and most severely in diabetes, but it may occur in a large number of different distur-

bances of health, and even in normal persons if the carbohydrate-intake is largely or entirely stopped. At times, however, it is certainly not due in large part to the diet, but is the result of some peculiar autochthonous disorder of metabolism. It has frequently been found in gastro-intestinal disturbances of various kinds, including the recurrent vomiting of children and of some adults, in gastro-intestinal disturbances of other kinds, after anesthesia, and in other conditions. In some of these instances it is certainly caused by the tissue-changes of the disease and not by the diet, but very often a determination of this point does clearly show that the carbohydrate-intake has for some time been much reduced, either deliberately, on account of peculiarities of the condition under treatment, or because marked anorexia or gastro-intestinal disturbance has interfered with the ingestion of much food of any kind. At times, in such instances, the use of larger amounts of carbohydrates will overcome the disturbance. Evidences of acid intoxication—they are, clinically, chiefly large amounts of acetone or diacetic acid in the urine—should be watched for if the carbohydrate-intake is being greatly restricted; and if such evidences appear, more carbohydrate should usually be added to the diet, if possible. The condition may be largely avoided in many instances by a proper consideration of this cause, and by giving carbohydrates in quantities approaching the normal in all cases, when this can readily be done, using, of course, a form suited to the individual.

As to the amount of carbohydrate required: The lowermost safe limit I have already given. This amount is practically always taken, unless some very decided disturbance of health has led to unusual restriction of the diet. The upper limit is determined largely by the effect of carbohydrates upon the digestive organs, although a limit must also be set upon the amount that we can wisely give, because of the manifest fact that very large quantities must cause abnormal demands upon metabolism. There is some ground for the belief that diabetes may be produced by a prolonged over-indulgence in carbohydrates, and the powers of assimilating this form of food are at times abnormally limited in the absence of diabetes. That these powers may then be easily overtaxed is shown by the well-known fact that a not inconsiderable number of persons that have not actual diabetes develop glycosuria if they indulge freely in starchy foods, which glycosuria disappears if one restricts such foods, and that a fair proportion of such persons ultimately develop diabetes if they take carbohydrates freely for a long time. A much larger number of persons readily exhibit so-called alimentary glycosuria if they take a large amount of sugar at one time.

The limitations that are imposed by the digestive organs are, however, more frequent and usually more marked than those referable to metabolism. Since foods of this class come practically from the vegetable kingdom alone, they contain cellulose and woody fiber in varying amount. In some of them the amount of this is

small, and in the preparation of most of them for the table much of it is removed. In a large proportion, however, it remains in small, but frequently noteworthy, amounts. This material is very difficult to digest; therefore large quantities of it act as a burden and a mechanical irritant to the gastro-intestinal tract. It also incloses the digestible and nutritive portions of the vegetable, to a large extent, and interferes with the digestion of these parts. The latter difficulty is, to a very important degree, overcome by fine division of vegetable foods and by proper cooking; but still a good many vegetables, as they appear on the table, are from this cause hard to digest and leave a relatively large undigested residue behind. Hence they are disadvantageous in extremely large amounts for normal persons, and often still more so, even in moderate amounts, for the sick. For the very same reason, however, a considerable proportion of them is extremely valuable for normal persons, and for many with digestive disorders, in order that there may be a fecal residue that will excite the lower bowel regularly to expel its contents.

It is to be remembered, on the other hand, that when only the portion of carbohydrates that contains little cellulose is used as a food, as is the case, for example, with rice or with preparations made from bolted flours, the whole substance is ordinarily almost completely digested by normal persons and by many of the sick. For this reason, and perhaps, also, owing to the nature of the digestion-products, such foods do not promote activity of the bowels, but very often tend to produce constipation.

A further important characteristic of carbohydrates is the ready tendency of many of them, especially if taken in large amount, and particularly if certain disturbances of digestion are present, to undergo acid and gaseous fermentation. The ready formation of acids is, indeed, another explanation of the laxative effect that many of them exert. This adds to their usefulness in stimulating intestinal activity, but it makes them equally disadvantageous when such stimulation is contraindicated. Their tendency to gas-formation is also one of the most important reasons for holding the amount taken by normal persons within bounds. With the sick, the tendency to gas-formation often makes it necessary to limit the intake of carbohydrates more or less rigidly to preparations that do not readily undergo fermentation. Potatoes and fresh bread seem to be usually especially likely to ferment, whereas double-baked breads, rice, and well-cooked cereal preparations of other forms are generally better borne.

The statements that have been made concerning the necessary limitations to be put upon this form of food should not, however, render less clear and impressive the fact that carbohydrates constitute ordinarily the largest, and, therefore, as fuel the most valuable, portion of our food. The average adult takes from 350 to 500 grams daily, that is, half to two-thirds of his total fuel-value comes from this source. Their importance becomes clearly evident when

we consider why a person with severe diabetes, whose power of assimilating carbohydrates is largely lost, hungers and emaciates. This person takes perhaps even more food than a normal man, but the element in his food that is normally of greatest importance as fuel is, in more or less considerable part, useless to him, and half or more of the carbohydrate that he eats may be excreted unused. Consequently, his actually assimilable food may be reduced to half or even less than half of what he ingests, and the total that he uses really falls far below the demand.

A normal person, then, can readily take 400 grams or more of carbohydrate daily, if this amount is, as is ordinarily the case, chosen largely from the foods that contain only a moderate amount or but little cellulose, and in considerable degree from those forms that do not readily ferment or disturb digestion. With persons that are not well the amount depends upon the individual circumstances. The diabetic must have his carbohydrates more or less rigidly limited, and obese persons, if they are to become less fat, must take sufficiently little of carbohydrates, as well as of other foods, to keep the energy-intake below the demand. Indeed, there is some reason for believing that carbohydrates and fats need especial restriction in obesity, as compared with the protein; for it is known that fats are directly deposited in the body as fat, and that an excess of carbohydrate is quickly transformed into fat. Protein, on the other hand, probably does not yield fat directly. This does not mean, however, that a large intake of protein does not at all further fat-formation, for protein yields energy freely and quickly, and the fats and carbohydrates are thereby spared from combustion. Hence, when much protein is used, the other foods go to form fat in the body. Vegetable foods that contain some starch and much cellulose—the green vegetables and tubers, such as beets, carrots, turnips, and parsnips, and, to some extent, those, such as potatoes, that readily undergo acid fermentation—are often extremely useful, when used very freely, because of the cellulose, in controlling sluggishness of the bowels. The same forms of vegetables are, of course, usually contraindicated in the contrary state of the bowels, or when the stomach is irritable. In these latter conditions highly starchy foods that are nearly free of cellulose, such as rice and arrowroot, and particularly preparations made from highly starchy foods that have been thoroughly or partially predigested by means of ferments, or more commonly by means of heat (double-baked breads, gruels that have been very long cooked and strained or dextrinized gruels), will often provide an acceptable nourishment, and will then also frequently relieve the irritative symptoms. When there is much tendency to gastro-intestinal fermentation, this is due most frequently to inability to digest starches. It is, in fact, very common to find marked difficulty in digesting starches, without any such direct clinical evidences of it as are given by gas-formation and similar symptoms. Whether these latter symptoms are present or not, there

are frequently a variety of other symptoms, such as headaches, general languor, nervous irritability, etc. In such circumstances the nature of the disorder may often be readily determined by examining the stools. In cases of this sort, many of the highly starchy foods must usually be narrowly limited to the extremely thoroughly cooked or partially predigested forms, and in many mild instances of this kind young and tender green vegetables which contain little starch do good largely through furthering normal activity of the bowels and thereby making it possible to avoid cathartics. Sugars themselves, especially cane-sugar and also foods containing much sugar, such as candies, table syrups, and many desserts, are well known to disagree even in moderate quantities in many cases of disturbed digestion. There is experimental evidence that sugar lessens the secretion of gastric juice when concentrated, and it certainly frequently causes irritation of the stomach if used freely. It also tends to produce diarrhea and gastric and intestinal fermentation in many instances. Used in moderation, however, sugars and preparations made from them constitute valuable and usually compact forms of food, and in the frequent cases in which they do not cause disturbance, sugar, honey, syrups, and similar foods can very advantageously be used in moderation in increasing an intake that is too low, and at times certain forms of food containing a great deal of sugar, for instance, honey, may be acceptable to the digestion in considerable quantity when ordinary cane-sugar and some other forms of sugar will be found to disagree. This is a matter that sometimes seems to be dependent upon individual peculiarities, but, as a rule, preparations containing chiefly glucose, maltose, etc., disagree less easily than the preparations of cane-sugar.

It is very important in cases with disturbances of starch or sugar digestion to remember the extremely large place that carbohydrates have in maintaining nutrition, and not, as is so frequently done, to order at once an elimination of starches and sugars from the diet just as far as is possible. It is extremely difficult, if this is done, to secure sufficient food, and nutrition is very likely to be impoverished as a consequence, and, furthermore, as I have already noted, it is extremely important for other reasons to have a considerable quantity of carbohydrate in every diet. Generally, it is quite possible for patients of this kind to take fair amounts of starchy foods if they are properly chosen; that is, chiefly the extremely thoroughly cooked and finely divided starchy foods, and particularly the very thoroughly double-baked breads.

Fruit.—The place of fruit in the diet is most properly mentioned under the general heading of Carbohydrates, as the chief influence of fruit as food is due to the carbohydrate-content. As actual energy-producers, many fruits have a very much higher value than is usually appreciated. Reference to the table toward the end of this article, which shows the food-values of many food articles, will sufficiently demonstrate this point. In addition to this, the

acids, salts, and probably other principles in fruits are unquestionably very useful for normal persons, as is shown with particular clearness by the effect of fruits in preventing some diseases, such as scurvy, or in actually curing some of these diseases. Fruits are, as is well known, very valuable in the treatment of sluggishness of the bowels, and they may sometimes be permitted when other forms of carbohydrate are more or less strictly contraindicated. For instance, some diabetics can take moderate amounts of fruit-sugar, which is largely levulose; while foods yielding glucose will be much less perfectly assimilated.

On the other hand, in many digestive disturbances fruits are contraindicated, and especially so in acute irritative disturbances or in the convalescence from many such acute disturbances. The digestibility of fruits is, in most instances, greatly improved by proper cooking. Indeed, in a very large proportion of the cases in which there is acute or chronic gastro-intestinal disturbance most raw fruits are not well borne, while cooked fruits often are.

Their effect upon the digestive tract is dependent chiefly upon two factors: the amount of cellulose, woody fiber, and acids that they contain, and the character of their peculiar individual flavoring principles. The latter differ much in their effect upon different persons.

With a good many people who are taking fruits and whose digestion is somewhat disturbed there are considerable quantities of small particles in the stools; these particles somewhat resemble minute seeds at times in their shape. Sometimes they are colorless; usually they are pigmented and of a brownish or reddish color. They clearly often come from fruits, especially from bananas, oranges, grape-fruit, and a number of other fruits that contain a dense pulp, and when they are present in considerable amounts, they appear to be due to some difficulty in digesting these fruits; consequently when many of them are found, raw fruits had best be restricted very severely, often giving only the juice of those raw fruits from which juice can be obtained, and whatever fruits are taken should be extremely thoroughly cooked.

FATS

The fat in the diet may, provided the total food-value is kept sufficiently high, be reduced more freely than may either the protein or the carbohydrate, but reduction of the fat means, as has already been noted, a much greater sacrifice in the fuel-value of the food than does reduction of protein or of carbohydrate. Among the disadvantages in the free use of fats I have already emphasized the fact that unless a considerable amount of carbohydrate is used coincidentally, free feeding with fats may produce more or less severe signs of acid intoxication. This is particularly true of milk-fat and its products, cream, butter, and cheese, and it is more especially true of these or other fats when they have not been properly kept.

Large amounts of the lower fatty acids are then present, and these are the substances that are most readily transformed into the acids that produce the intoxication.

This effect of fats is, by some observers, considered to occur exclusively when the carbohydrate-intake has been reduced very low. Undoubtedly one can determine, as a rule, as I have already stated, when signs of this intoxication appear, and are dependent on the diet, that the carbohydrate-ration has been greatly reduced for some time, but I am convinced that this is not always the case. It is certainly not equally the case with all individuals. I have often seen varied symptoms, such as languor, foul breath, irritability, general poor nutrition, and frequently more or less active gastro-intestinal disturbance, associated in a considerable proportion of these cases with acetonuria and diaceturia, in persons who, either from habit or for the purpose of improving nutrition, had been using fats very freely; and these symptoms disappeared more or less completely after a restriction of the fats, even though the carbohydrate-ration had not been low. This is particularly common in children and in adolescents. Often evidence of poor fat digestion may be found in the stools, but sometimes it cannot; nevertheless, restriction of the fats overcomes or greatly benefits the disorder. These cases constitute frequently a fairly distinct clinical syndrome, which I not infrequently see and which can often be suspected from the symptoms. One's suspicion can be confirmed if there is poor fat digestion by examining the stools, or the suspicion can be made a probability by learning that fats have been freely used in the dietary, usually in an effort to improve the nutrition, which is frequently poor. The free fat diet very commonly results in intensifying the poor nutrition. I am, therefore, fairly well convinced that there is a decided limit to the amount of fat that can be cared for by many persons, not only by the digestion, but by the metabolism, even though carbohydrates be freely given with the fat, and this limit is with many persons not a high one. Children especially can often take but moderate amounts.

Digestion also often suffers readily if much fat is used—much more readily from this cause than is at all frequently appreciated. The commonest kind of digestive disorder that fats produce is gastric disturbance—reduced appetite, gastric uneasiness, nausea, and occasional vomiting, and these symptoms are often associated also with the foul breath and the general symptoms mentioned above. On the other hand, there may be little or no gastric disturbance for considerable intervals, and then occasionally more or less severe gastric outbreaks. A considerable group of cases that are not such are called recurrent vomiting, and these are often due to overfeeding with fats, or inability on the part of the stomach to take normal quantities of fats. Often the disturbance is not solely gastric, or perhaps is entirely intestinal; in that case one commonly finds in the stools large quantities of soaps, some fatty acids, or in some cases noteworthy amounts of neutral fat. The excessive quantities of soaps are at times accom-

panied by diarrhea, which is sometimes very difficult to control by any means except by diet; somewhat commonly they cause, on the contrary, constipation, with hard, dry, pale stools. The cases in which there is much neutral fat in the stools are likely to exhibit diarrhea.

All these disturbances from fats are particularly common in children who have delicate digestion or who are out of health, and especially in persons, such as tubercular subjects, whose digestive powers have been pretty freely taxed, particularly when they have been very freely given fats in an effort to improve their nutrition. But they occur with a great variety of cases, and when gastric disturbance occurs on any diet that contains a relatively large proportion of fats, as, for instance, with ordinary milk in acute disease, the disturbance is most commonly due to the fats. Recognition that this is the cause, and almost complete temporary elimination of fats of all kinds from the diet, and then carefully working back to the amount that the patient can stand, often serve to overcome the trouble promptly and more effectually than any other measure. It will frequently be found that there is a permanent difficulty in taking much fat; for instance, many persons can take partially skimmed milk in any reasonable amounts, but will be readily upset by moderate quantities of whole milk.

With most normal persons, if the amount given is not very excessive, the presence or absence of disturbance from fat is largely a question of the kind of fat used and the way in which it is prepared, but with many persons whose digestion is not normal, fats of any kind when used in considerable amounts produce disturbance, and restricting them closely may, in such cases, clear up most or all of the symptoms. Indeed, it may be fairly said that fats cause much more frequent gastric disturbance than do any other forms of food. It is but natural that this should be true, for they have been shown to depress gastric secretion, they delay the emptying of the stomach, since they are long retained in the stomach, and at best they undergo no digestion in the stomach except when emulsified, and then probably but little; also when cooked into other foods—and this is very frequently done with a great variety of foods—they delay the digestion of the protein and carbohydrate by preventing the digestive juice from attacking them properly, and thus cause mechanical burdening of the digestive tract and give opportunity for all the foods to undergo fermentation and putrefaction.

As a general rule, those fats that are fluid or that melt at a low temperature are the most digestible. Whole milk, butter, olive oil of good quality, and many forms of soft cheese can be taken by most persons with reasonable freedom, and cream can be used in moderate amount without any resultant ill effects, but when there is fat intolerance, even these foods, in moderate quantities, will often cause disturbance. The manner of preparation in some instances largely determines the amount that can be used through its effect on the palate and on the readiness with which fats and the other

foods taken with them can be digested: fats, more than any other foods, being likely, with persons of delicate susceptibilities, to prove repulsive in their appearance and taste unless they are served in an especially attractive form. They also become less digestible, as a rule, and interfere more with the digestion of other foods, in proportion to the intimacy with which they are incorporated with other foods in course of their preparation for the table.

Abnormal reduction of the fats in the diet, except for the great reduction in fuel-value that this entails, has few known evils associated with it. Infants certainly suffer readily in general nutrition from lack of fats, however, and appear to be likely to develop rickets and sometimes scurvy, although their food is practically always abnormal in other particulars at the same time if the fat is low, and these disorders are probably due quite as much to this as to the lack of fats. Adults likewise, however, seem inclined to scurvy when the fats are much restricted, but only when other conditions of hygiene are bad at the same time. It is, at any rate, known that many adults have normal health, although they continuously take extremely little fat.

A fact of the greatest dietetic importance in relation to fats, in contrast to what has been said above, is their great fuel-value. This has already been repeatedly insisted upon and its extent mentioned. It is of the utmost importance in conditions of malnutrition, particularly when the capacity for taking some of the other foods is crippled. The most severe and striking instance of such crippling is diabetes. In tuberculosis, too, and in various other common conditions in which chronic malnutrition is one of the important elements, the judicious use of fats is of enormous value. As has been noted, it must always be borne in mind that digestion and metabolism may readily rebel if very large amounts of fat are given; and, unfortunately, digestion does rebel only too frequently. With a reasonably large carbohydrate-ration, however, the metabolism of many persons will stand a large amount (150 grams or even more) of fat daily without any ill effects, and if the fats are carefully chosen and well prepared for the table, abundant quantities will be accepted by most digestive organs.

In the average normal diet 75 to 100 grams of fat are taken daily, but the amount varies a great deal. In order to equalize labor in digestion and metabolism, and in order to secure a proper variety of food, a normal ration of 50 to 100 grams is desirable. In case it is desirable, the amount may often be raised to double the latter quantity and at times to even more.

WATER

A supply of energy is, as has been stated, the most immediate essential to the continued life of the organism, but, in a sense, a supply of water is quite as important, or even more so. It is to be remembered that, except in conditions of extreme emaciation, the organism has a large amount of energy in reserve, in the form of

fat; and a considerable amount in the form of carbohydrate, and even in the form of protein. A large part of this can be used without serious harm if the circumstances demand it. In addition to this, if the needs are not yet supplied, a large part of the essential protein tissue can be used as fuel before this causes death. It is, therefore, impossible to cut off the supply of energy immediately, even by absolute starvation.

The results of an entire cessation of the supply of water are much more quickly dangerous. It is, to be sure, almost equally impossible to stop the supply of water immediately by stopping the intake as to stop the supply of fuel. Hoppe-Seyler's picturesque statement, that "all organisms live in water and, in fact, in flowing water," is evidently not overemphatic in relation to the human organism, when one considers that the nitrogenous tissues are themselves, roughly speaking, four-fifths water, and that, besides this, the cells are bathed in fluid. Much of this water in the organism can be made use of for other than its normal purposes if the normal supply ceases, the tissues being then broken down and the water set free. Indeed, while a loss of 50 per cent. of the solids of the tissues causes death, it is said that 70 per cent. of the water of the tissues may, at times, be used to slake tissue-thirst if the outside supply is stopped. But the very large proportion of water in the organism is itself sufficient evidence of the need for a free supply. It is common knowledge that prolonged thirst is more dangerous than prolonged hunger, and that it causes death much sooner. Also, while the suffering from a sense of hunger usually decreases or disappears before death from starvation occurs, persistent lack of water causes most agonizing distress to the end.

It is not surprising that this is true. The chemical and physical body-processes cannot continue normally if the concentration of the tissues and of the body-fluids is decidedly increased; and the amount of water in the organism has to be kept within pretty narrow limits or serious symptoms develop. A loss of tissue means merely so much functionating power gone, but the supply of this power is so largely in excess of the minimal requisite that a good deal may be lost without any immediate danger. A considerable loss of water, however, causes immediate danger that the body-machine will stop working, just as it will stop working without oxygen, for the normal chemical and physical processes will not take place. The organism does, to be sure, rob its own tissues of water when the outside supply ceases, even more eagerly than it robs them of solids when starved; but with an absolute cessation of the outside supply there must evidently soon be a limit to this use of the water of the organism. The amount thus obtained is rapidly lost in excreting tissue-products, and a continuance of this process soon means an undue concentration of the body-tissues and fluids. This, if marked, soon causes death.

The amount of water in the organism can be maintained at a

level slightly below the normal without causing death, and this occurs in many acute and chronic diseases in which there is interference with the intake: for example, in esophageal or pyloric obstruction, and in cases exhibiting much irritability of the stomach, and also in cases in which excessive loss occurs from vomiting, diarrhea, hyperhidrosis, polyuria, or hemorrhage, when the loss in any of these last-mentioned conditions cannot be quickly and completely made good by drinking a sufficient quantity. If, however, the water in the organism remains for any considerable length of time decidedly below the normal point, it does so, at best, to the great discomfort of the patient and to the decided disadvantage of his body-processes.

For the simple purpose, then, of securing a proper course of normal body-metabolism it is important to see that sufficient water is taken in the normal way. This is not done by a very large proportion of humanity,—particularly, I think, by a large proportion of women,—owing largely to unconsciously formed habits. Many indefinite and sometimes marked disturbances of health may often be much improved by attention to this point. In cases in which there is obstruction of the upper alimentary tract or great irritability of the stomach, or in which other factors make it impossible for the patient to drink sufficient water, it is of much importance to secure a sufficient intake by artificial means—that is, usually by enemata; in occasional cases, when necessary, by hypodermoclysis. The importance of this is overlooked with extreme frequency. Its effect is evident in conditions in which nutritive enemata are used; their good effects have been shown to be in large part due to the water that they supply to the tissues, rather than to the solids of the food thus administered.

There are also purposes in recommending moderately free water-drinking other than the simple maintenance of a proper dilution of the body-fluids. A moderate amount of water must be present in the stomach during gastric digestion in order to dilute the gastric contents properly, and it has, in recent years, been determined that the stomach itself carries out this dilution quite accurately if the necessary amount of fluid is not swallowed. Furthermore, absorption from the intestines is not so good with a very dry diet as with one containing a moderate amount of fluid, and there is no doubt that the kidneys are more readily damaged if the urinary solids are passed through them in concentrated solution than if the solution is reasonably well diluted.

In addition to these facts, water, of course, flushes the system and washes out waste-products. Repeated studies have, indeed, demonstrated that even when one is accustomed to drinking water with ordinary freedom, the use of an extra quantity always temporarily increases the output of nitrogenous end-products, through flushing the organism. The importance of large amounts of water in acute or chronic cases presenting toxic states of infectious or

metabolic origin therefore, becomes evident. Free water-drinking is made use of for the purpose of relieving toxemia very frequently at the present day, but appreciation of its value for this purpose has not become half so general or so decided as it should be.

In addition to this, very free water-drinking appears to increase the activity of metabolism; I have found experimentally that it increases metabolism for a long period, and perhaps continuously. Generous amounts are, therefore, desirable in conditions that are believed to be associated with sluggish tissue-processes.

Excess in the use of water, on the other hand, has undoubted evil effects. It unduly dilutes the digestive juices, and it burdens the digestive and circulatory organs. Probably, also, the passage of a large excess of water is harmful to the kidneys. It is not apparent that it does marked damage to the chemical processes in the tissues, for any noteworthy excess is immediately excreted through the kidneys, except in abnormal conditions associated with dropsy—the organism being very careful to limit the amount of water in the tissues, when it can, in an upward direction, as well as in a downward. It is, however, entirely probable that continued excessive intake may damage tissue processes, and, clearly, any considerable excess should be avoided in order to prevent digestive or circulatory strain. Very free use of water should not be permitted, therefore, except for definite purposes. In many disorders of digestion and circulation the amount must be carefully limited to a low normal, and in some of these conditions—for example, in treating edema, cardiac insufficiency, or aneurysm—the amount is, for a time, often kept purposely much below the normal.

The determination whether sufficient fluid is or is not being taken should be made, in cases in which this is of some importance, by observing the total amount of the twenty-four-hours' urine. Except in dropsical conditions, if the total urine falls much below 1500 c.c. (about 45 ounces), more fluid should be taken, provided there is nothing peculiar to the individual patient that contraindicates this. If the urine falls distinctly below 1000 c.c. (about 30 ounces), decidedly more water should be taken unless contraindicated. This means, usually, that about 1500 to 2000 c.c. (1½ to 2 quarts) should be taken as fluid, in addition to the water contained in the solid food. If the person under observation sweats freely, he will often have to take very much more than this. The amount may, without harm, be for a long time greatly increased above this point if there is special occasion to do so, and in severe toxemias it is often highly desirable to have the urine maintained at at least 60, better 80 or 100, ounces, but usually in order to spare the digestive tract and circulation the amount should be limited to about two quarts unless there is some distinct reason for an increase.

There has been much discussion of the question whether water should be taken with meals. I think that the answer should definitely be a limited affirmative. As was noted, the stomach re-

quires some degree of dilution of its contents in order to perform its work properly. A moderate amount of fluid will, therefore, do good rather than harm. Besides this, it is so difficult to take much food without fluid that many normal persons—and, even more, many of those that need to have their intake increased—would frequently take too little food if water were withheld at meals. The reputed effect upon obesity of reducing the amount of water taken is probably largely dependent upon the last-mentioned fact; when the water is restricted, the patients voluntarily take less food than before. In treating obesity, therefore, the water may wisely be reduced in most instances.

Sometimes even a moderate amount of water causes a diseased stomach to rebel; and in occasional cases digestion and absorption go on better when the food is very much concentrated. This is particularly true in dilatation of the stomach. At most, very little water is absorbed from this organ normally, and if the gastric contents cannot be readily driven on into the intestine, they are retained in the stomach; consequently the greater their bulk, the greater the burden upon this viscus. Water is frequently very damaging, also, when the stomach is so irritable that it is likely to reject anything that enters it. In such instances the amount of water taken by mouth should be extremely limited, and frequently for a time none should be given in this way; but a supply should then generally be furnished to the tissues by rectum if the restriction is continued for any considerable period. In diarrhea the amount of water—particularly of cold water, for cold often stimulates peristalsis—must be limited; and in dropsical conditions a moderate or, for a time, a pronounced reduction of fluid is frequently important.

SALTS

Salts of various kinds are an essential part of the diet. Numerous salts are used in building tissue, and they are also required in the body-fluids to maintain the physical and chemical conditions that are essential to a continuance of the varied processes that take place within the body. For years we have had some most striking evidence of their physiologic importance, and this has been much emphasized by recent work. In the course of the body processes salts are set free and are excreted, and the loss must be replaced. In the growing organism, also, an extra amount is required for the construction of new tissue. We have, however, not sufficiently clear knowledge of most of these matters, and not enough control of the salt intake through diet to make this a point of great dietetic importance, as yet, in most instances, and the supply of salts does not, as a rule, need much supervision in normal persons, as a normal mixed diet provides sufficient. There are some evidences that here, as in many other ways, nature regulates our appetites so that we unconsciously fulfil her demands. According to Bunge, for instance, one's appetite leads one to eat table-

salt (sodium chlorid) freely with vegetables, because the latter contain much potassium phosphate. This substance, he believes, robs the organism of sodium chlorid by undergoing a chemical interchange with the latter, sodium phosphate and potassium chlorid being then formed and quickly excreted.

A certain number of abnormalities that are clearly due to changes in the demand or in the supply of salts are, however, observed. In the convalescence of many diseases there is at times an unusual longing for large amounts of table salt, evidently because large amounts are often lost during disease. Frequently also one finds persons habituated to the use of large amounts of table-salt. In the latter cases the practice is best stopped, if it is a pure habit, as it is likely to damage the digestive organs and the kidneys. Occasionally, however, persons exhibit for a long time an intense desire for unusual quantities of salt, and in such instances there is probably some nutritional cause for the salt-hunger. Though the cause is not clear, the salt should, I think, be permitted them, in at least moderately generous quantities. It is known that large amounts of salt increase the metabolism of protein, and this sufficiently suggests that there may be occasional real need of extra quantities.

Sometimes limited forms of diet do harm by limiting the supply of some salts below the demand. It has been determined, for example, that a diet poor in calcium salts produces rickets in young animals and children, and the relation between scurvy and beri-beri and a limited diet is well known. It is not clear that these latter diseases are due to a lack of salts, but it is highly probable that this is an important factor. A prolonged milk-diet sometimes leads to anemia, perhaps because milk contains but little iron.

The chief instance of existing disease in which the intake of salts needs clinical restriction, so far as we now know, is in treating nephritis and dropsical conditions, particularly when the dropsy is due to nephritis, and in gastric hyperchlorhydria. Sodium chlorid, which constitutes the chief bulk of the salts in the food, is normally excreted in the urine in amounts varying from somewhat below to considerably above 10 grams. It is perfectly evident that the labor of any damaged kidney can be considerably reduced by greatly reducing the salt in the food, and that such a decrease is important in nephritis in general. When dropsy occurs, it appears to be frequently due more or less largely to retention of sodium chlorid and the water retention that is consequent upon this, this retention being sometimes due directly to renal insufficiency, sometimes not, but renal insufficiency being the most striking and best recognized cause of such a state. The complete or almost complete elimination of salt from the diet is now frequently practised with nephritis that is associated with dropsy, and with, at times, good results, this reduction of the tax upon the kidney permitting of the excretion of the sodium chlorid which has been retained, the water going out with it. The same measure has, however, some value

in cardiac dropsies, and it seems to be of use in certain cases of obesity, particularly in those whose circulation is poor, for these persons frequently accumulate an undue amount of fluid in their tissues, and some of their excess in weight is due to this, and whatever the cause of the accumulation, cutting down the intake of sodium chlorid causes often a reduction of their weight by the elimination of sodium chlorid, and with it of the water. In irritative states of digestion also, especially in gastric irritability and hypersecretion, free use of salt should be interdicted, because it tends to increase the irritation, probably through the increased activity of physical processes that the presence of so much salt causes.

The intake of particular salts other than common table-salt cannot often be regulated to any important degree through the diet with the exception of iron, and to some extent calcium, as was mentioned. Anemia, especially in young children, is sometimes due simply to the diet, chiefly to an excessive and long-continued milk diet. It is probably largely owing to the fact that they contain more iron that the addition of meat, eggs, and green vegetables so commonly overcomes such conditions. Iron-containing foods are undoubtedly an important part of the diet in chlorosis, also, and in secondary anemias of various kinds. The foods containing considerable amounts of calcium are, of course, extremely important for the very young; commonly they will get enough, and, indeed, it is only when the diet is somewhat irrationally arranged that they are likely not to have a sufficient intake.

In this connection it is also desirable to note that a largely vegetable diet tends to make the urine less acid or neutral, sometimes alkaline, because of the salts contained in vegetables, while nitrogenous foods tend to increase the acidity of the urine because of the large amount of acid ions that the sulphur and phosphorus in them yield. This point is of some importance in a variety of conditions in which the reaction of the urine is a factor in determining the progress of the case, chiefly in inflammatory conditions or calculus of the lower urinary tract.

CONDIMENTS AND STIMULATING BEVERAGES

Condiments.—In addition to the essential substances already discussed, the diet of human beings regularly contains larger or smaller amounts of substances that are used, not as foods, but as stimulants to the appetite and the digestion, some of them being also stimulants to the circulation and the nervous system. Pepper and other spices are pure condiments, and are taken almost solely for their effect upon the appetite and the digestive organs, and much of the table-salt used has no other purpose. Moderate amounts of these seem not only to do normal persons no harm, but to be almost necessary, in order to insure a proper consumption of food. When used freely, however, they act as persistent irritants to the digestive tract

and the kidneys, through which most of them are excreted, and probably also to the circulatory organs and to the organs engaged in metabolism. Normal persons should, therefore, use them carefully; and, with most persons that have gastro-intestinal, circulatory, or renal disease, their use should be closely restricted and often forbidden. At times, however, they may wisely be used by such persons, under supervision, for the purpose of stimulating a flagging appetite or a sluggish digestion. This needs to be done with some caution, but in various states of malnutrition, when the digestive organs and kidneys show no noteworthy disease, condiments are frequently useful for their effect upon the appetite.

Beverages.—Tea, coffee, cocoa, chocolate, and alcoholic drinks are, like condiments, used to stimulate the appetite and digestion; but they also stimulate the nervous system, and some of them stimulate the circulation. In addition to this, several of them—in fact, all, as they are ordinarily used—have more or less food-value.

A large proportion of meat-extracts and such preparations, as they are found on the market, and also home-made beef-tea and broths,—unless specially prepared,—act chiefly through the stimulating effect of their constituents upon the appetite, the secretion of gastric juice, the circulation, and the nervous system, but only to a very limited degree as actual foods. Most commonly, therefore, they belong in the same class, practically speaking, as tea and coffee, although they are frequently so prepared that their food-value is somewhat increased.

The question of the use of beverages is, owing to the especially stimulating effect of most of them upon the nervous system and the circulation, and in most instances upon the kidneys, a more complicated one than that concerning the use of simple condiments, and, as a rule, it is a more serious question.

Cocoa and *chocolate*, in the amounts in which they are generally used, are certainly not likely to do harm to any organs except those of digestion, and their influence upon the latter is due almost solely to the amounts of sugar and fat that they contain. If sugar and fat are not well borne, cocoa, ank particularly chocolate, need to be very carefully used or forbidden altogether; and unbridled indulgence in them is, naturally, a bad practice for normal persons, for the reason just given, and also because a harmful amount of their active principles may perhaps be taken. When they agree, however, limited amounts of chocolate and cocoa are often valuable as foods to normal persons and the sick as well, both because of their essential food-value and because they are usually taken with very useful amounts of milk or cream.

Tea and *coffee* are more stimulating to the nervous system, the circulation, and the kidneys; consequently their use needs much more careful supervision. There is no tangible evidence that great moderation in their use produces any ill effects with entirely normal persons, and it is unjustifiable to object to long-established general

customs unless some very good reason for doing so can be found, for in an impressively large proportion of instances investigation has already demonstrated that such customs have been developed through unrecognized but real physiologic demands. With persons, however, whose nervous systems or circulations are highly labile, whether these persons are otherwise normal or not, tea and coffee readily do damage; and with such persons their use needs careful regulation. It is so easy for any one almost unconsciously to increase the amount taken that excess is, as a matter of fact, extremely common, and needs to be regularly looked for. In digestive disturbances they also often do harm, coffee being especially disadvantageous in irritative states of the stomach and bowels, and particularly in hyperchlorhydria.

Alcoholic Beverages.—It seems to have been established with reasonable clearness that one of the actions of alcohol is to serve as a food. It is not a tissue-builder, but is an energy-producer, and thus spares the tissues from consumption. It is still more clear, however, that its evil effects may be very profound, even when acute intoxication is avoided. There is, I think, no rational doubt that small amounts of alcohol are at times useful with those that are out of health for their stimulating effect upon the appetite and upon digestion, and occasionally for their effect upon other functions. It is not my province, however, to discuss the action of alcohol as a drug. As a food, when the intake of other foods is necessarily low, alcohol has a certain place, although a limited one. There is no good evidence that small amounts, taken temporarily, produce any bad results; except when there are especial contraindications to its use, as, for example, is often the case in inflammatory and other nervous diseases that are associated with excitement, in irritative conditions of the digestive organs, and in many circulatory and most renal or hepatic disorders.

The food-value of alcohol itself is, however, of comparatively little moment, because only small amounts can be given without producing toxic effects, and the toxic effects are a much more important consideration than the food-value, but the food-value of some preparations of alcohol is larger than is commonly appreciated—not because of the alcohol contained therein, but owing to the other substances, chiefly to carbohydrate. Beer, ale, stout, and porter usually contain from 4.5 to 5.5 per cent. of carbohydrate, and sweet wines may contain even more, some sweet Rhine wines, for instance, showing over 8 per cent., while sweet champagne may contain more than 11 per cent. Consequently, if the other constituents of these beverages do not disturb digestion, the total food-intake can often be very largely and pleasantly increased by their use. That the danger of inducing the alcohol-habit has to be held in mind is self-evident and important; but with those beverages that contain only a small amount of alcohol this is unlikely with patients that have a reasonable amount of self-control. The moral character of the patient in this regard, must, of course, be decided in each case; but it is clear that the presence of functional nervous disorders

or of any condition associated with mental depression must commonly make the use of alcohol as a food or a beverage unwise, on account of the likelihood of forming the habit.

The above-mentioned preparations of alcohol that contain carbohydrate are, of course, contraindicated, as a rule, in gout, diabetes, and obesity, and they disagree in many disorders of digestion. Indeed, in diseases of the liver and kidneys, in gout, in arteriosclerosis, and many other cardiovascular conditions, in obesity, and in many gastro-intestinal disturbances, the use of alcohol frequently needs to be most rigidly interdicted, as at most very carefully limited.

The decision whether a normal person shall use alcohol is not, ordinarily, under the control of the physician. If the question is put to him, the most rational answer seems to be that while the habitual use of alcohol may, in rare instances, be desirable, owing to some actual disturbance of health, it is never desirable with normal persons, and is nearly always ultimately harmful, even when the amount taken is very moderate. Used as a beverage, even in very limited quantities and only occasionally, it appears to produce slight harmful effects temporarily in many persons who are not evidently diseased, so that it is impossible to say that even the moderate and occasional use of alcoholic beverages is free from harmful results in normal persons. Very small amounts in dilute form certainly do little if any harm, but it is very unusual to find it used, if used at all, in such amounts as to be surely safe.

In some instances its use in any quantities certainly cannot be looked upon with complacency. The dependence upon it that is likely to develop in those of weak moral character, or in those that are constantly overworked, forbids their use of it, and I would especially direct attention to its harmfulness in persons whose circumstances of life are such as to make them especially susceptible to the dangerous toxic effects of alcohol, particularly the large group of humanity that in their work are necessarily exposed to other toxic influences; for example, workers in lead, mercury, carbon bisulphid, carbon monoxid, or many other chemical substances. The evil general effect of these substances is very largely reinforced by even a moderate amount of alcohol, and persons exposed to these poisons should abstain absolutely.

There is a wide-spread belief that small quantities of alcohol are good for old persons. This seems to be pure tradition, with no substratum of fact. If an old person has a poor appetite, a sluggish digestion, or some other form of disorder, the symptoms may sometimes, but not always, be relieved by taking small amounts of some alcoholic beverage. A normal old person, however, does not need alcohol any more than a normal young person. Indeed, he seems to need it less, for he requires less total energy-intake per day than does the young person.

Non-alcoholic drinks may be mentioned merely to say that a large proportion of them contain considerable amounts of sugar,

and that the use of them should, therefore, be closely supervised in many disorders of digestion, in diabetes, in obesity, or in any other condition in which sugar is contraindicated. The flavoring principles also often disagree.

PREPARATION OF THE FOOD

Preparation of the food is a feature of dietetics that is of the utmost importance, but it is so largely a question of careful detail that it must be left to articles that deal with details and to books especially devoted to such subjects, for it is not in place here. There are, however, a few leading facts that do need mention, although a large proportion of them are common knowledge.

There are certain general principles that are applicable to all forms of food: in the first place, if one desires to increase tissue, and, therefore, to increase the intake, there should be especial care that the food is prepared and served in as appetizing a form as possible. This fact is often sufficiently understood, but the point is by no means properly followed up in actual practice, and it is frequently woefully neglected in institutions for the sick. There are many easy and inexpensive methods of making foods acceptable to the palates of the sick poor that are used far less than they might be, largely because they are not known or because the slight effort that is involved in carrying them out is avoided.

On the other hand, in cases in which the diet should be restricted one needs, in many instances, not only to limit the amount of food, but deliberately to see to it that the manner of preparation is, while wholesome, not too tempting; otherwise the total intake will still often remain too high.

It is also necessary to watch over the methods of preparing food for another general purpose: the more elaborate the composition of food-preparations, the more difficult it is, as a general thing, for digestion and metabolism to deal with them. It has been shown by exact investigations that digestion and absorption are less complete, in many instances, when a number of simple foods are taken coincidentally than when but one of these foods is taken alone, even though the latter be used in amounts equivalent to the previous total. Also while, as I have stated, a mixture of protein and carbohydrate, at least, is essential to normal metabolism, it has been almost as clearly shown in relation to metabolism, as it has in relation to digestion, that a variety of forms of these foods and of fats may cause more tax than a small number. Hence, when digestion or metabolism is already impaired, we often limit the variety of food-articles as largely as can properly be done; and restriction of variety in the manner of their preparation is very commonly still more needful. One of the main reasons for this is that many preparations so intermingle the different foods used that each, so to speak, has to wait until the others are cared for by the digestive juices before any can be well digested. Conse-

quently, digestion is delayed on all sides, and proceeds only bit by bit, and the digestive organs are overburdened and irritated by the undue retention of food; and, furthermore, time is given for fermentation and putrefaction to occur. Butter, eggs, and sugar may, for example, be well digested when not artificially mixed, but pastry may be very badly borne by the same person.

In many preparations, also, the food is rendered relatively indigestible or innutritious by the manner of preparation, when, perhaps, even a slight change in the method would have made it wholesome. Meat roasted a long time, until thoroughly done, is less digestible than rare meat, and meat slowly boiled is less nutritious than that quickly boiled.

Furthermore, and this is often more important, elaborate methods of preparation involve the use of relatively large amounts of condiments and sauces of various kinds, and these substances, when used very freely, probably do harm throughout the whole course of their progress from their ingestion to their excretion.

While one must grant that a considerable proportion of persons, particularly among the well-to-do, eat too much total food and too much of certain food-articles, there can, I think, be little doubt that many more persons are damaged by the culinary form in which they take their food. Overeating consists, I believe, more largely in this factor than in any other; that is, persons in comfortable circumstances more frequently do themselves harm by taking unwholesome food freely than by mere excess in amount.

In this connection may be mentioned the temperature at which foods should be eaten. This cannot, of course, be regulated within narrow limits, but it should be controlled to the extent of preventing the habitual use of very hot or very cold foods or drinks. This is very commonly the cause of chronic gastric and intestinal disease, and it often causes acute disturbance also. Ices, and other iced drinks, when taken very slowly and in small amount, are so largely warmed on the way down that they do no harm, but the complacent American habit of taking them in unlimited quantities, in spite of the objections to them, is a fruitful source of evil. Persons need to be taught that ice-water does not allay thirst so well as cool water, and does much more harm. Often, in very acute gastric disturbance, however, food or fluid when served very hot or very cold, is comfortably retained by the stomach when otherwise it would be rejected or give distress.

Another general fact is of extreme importance to the severely sick, but also to others, and it is true of all foods. It is evident without demonstration that the more finely divided and the more nearly in solution foods are when taken, the less irritation do they cause, and the more readily are they digested and absorbed; therefore in acute disease and in cases of difficult digestion fluids or semifluids, or, at most, finely divided forms of solids, are used. Often even a small portion of poorly subdivided food may cause grave disturbance in such cases. On the other hand, it is common experience that in cases

of considerable duration fluids and very finely divided food-articles readily become repulsive. For this reason, and because the gastro-intestinal tract, as well as other organs, should not be prevented from performing its normal functions when they can be carried out without damage, such foods should not be used for an unnecessarily long time.

Preparation of Meats.—In relation to the preparation of the special classes of foods, only a very few details need mention here. Meats, if finely divided, are usually slightly more digestible when raw than when cooked. There is, however, danger of bacterial and parasitic infection when they are used raw. For this reason, and still more because they are usually more palatable when cooked, they are in this country seldom taken in the raw state.

The methods of cooking have an important influence upon their digestibility as well as upon their palatability. The chief methods are broiling, boiling, frying, and roasting. As ordinarily done, broiling and roasting are the only thoroughly acceptable methods.

Frying is never wholesome, because, when cooked in this way, meats are usually harder, more of the albumin being firmly coagulated, unless the frying is very well done; and because also the fat used in frying so permeates a large part of the meat as to make it difficult for the gastric and intestinal juices to get at the lean and digest it.

Boiling, when well done, is a good method; when not well done, a poor one. The chief point of importance concerning boiling is that raising the temperature slowly removes salts, extractive substances, and a very considerable part of the nutritious and very digestible soluble albumin. On the other hand, placing the meat in water that is already nearly or quite boiling quickly coagulates the external portion, and this prevents the extraction of much nutritious material, for the coagulated portion acts as a more or less impervious coating. Hence, when the meat itself is to be eaten it will taste better if boiled quickly, because the substances that lend flavor are extractives, and these are largely removed in slow boiling. The meat will also be more nutritious when quickly boiled. If, however, it is being boiled in order to make soup or broth, slow boiling is essential in order that the soup may be well flavored and nutritious.

In all instances, when cooking meats, it is to be remembered that prolonged cooking at a high temperature firmly coagulates the most digestible and nutritious portions of the meat, and thereby makes them less digestible than when they are cooked for only a short period. Prolonged cooking, particularly prolonged boiling, may dissolve and loosen a good deal of the denser connective tissue and make the meat seem, upon superficial observation, more tender, but as an actual fact it merely makes the meat more easily fragmented, while the individual fibers themselves are harder to digest.

It is a well-known fact that keeping many meats for some time before they are eaten is essential to making them tender and highly flavored. There have been various theories as to the cause of this, but recent investigations have shown that it is the result of a natural

partial predigestion of the meats. The ferments present in the tissues, if time is given them, carry out a partial autodigestive or autolytic process which softens the meats, and substances formed in this process heighten the flavor. This is one of the many instances in which accurate investigations have ultimately demonstrated that many, if not most, such general customs are based upon rational physiologic principles, although the customs may have been empirically established.

The Preparation of Carbohydrates.—The preparation of carbohydrates is, in many of its most important parts, carried out before these foods are purchased, except in connection with the fresh vegetables. In the preparation of cereals, the indigestible cellulose and woody fiber are usually removed and the cereal is frequently finely ground. The effect of this is to remove most of the irritating elements of the food; consequently the only way in which such preparations are likely to upset the digestion afterward is through the possible occurrence of fermentation or through promoting constipation. With irritable digestive tracts only cereals that are finely ground, largely freed of cellulose, and thoroughly cooked are permissible. With sluggish digestive tracts, on the contrary, especially when there is constipation, the less finely ground cereals, more particularly those that contain all the elements, including the cellulose (whole-meal preparations), are valuable.

In the domestic preparation of carbohydrates the elements of chief importance in sparing the digestive tract are fine division of the food and thorough and prolonged cooking. The cooking, as is well known, causes the starch-granules to swell and ultimately to rupture, and this accomplishes the most important purpose in their preparation, which is to make the starch accessible to the diastatic ferments of the digestive tract. When prolonged, cooking also converts some of the starch into fluid starch, and even partially predigests some of it into dextrins, small portions of it, indeed, becoming digested as far as the maltose stage. Cooking also softens the cellulose and thus helps to break up the food into small particles, or to make it easy for the individual to do so in mastication. For this reason it is of vastly more importance than is usually recognized to have carbohydrate foods, and especially those that contain a good deal of cellulose and woody fiber which is closely intermingled with the other substances, cooked very thoroughly. Such foods, for example, are all the green vegetables, tubers, such as beets, carrots, parsnips, and turnips. Unless young and tender, they are relatively indigestible, at best, and they become a suitable food only after very prolonged cooking. For persons who have troublesome digestions they should also be very finely divided, as by being put through a colander.

The Preparation of Fats.—The most important element in the preparation of fats is to avoid their too intimate mixture with the other foods with which they are served. A French salad-dressing, for example, in which the oil is nearly free, is with most persons com-

paratively digestible, while a mayonnaise is, as a rule, very indigestible. This point is elsewhere sufficiently dwelt upon.

Another point, however, is frequently of much importance: With delicate digestions, the chief factor in making the fats digestible is usually to give them in a finely divided form or in such form that mastication will finely divide them. The first is done with artificial emulsions and the latter can sometimes be done in cooking. For example, in addition to the effect upon the appetite, a piece of greasy, dripping bacon is much less easily digested than a piece that is crisply cooked, probably chiefly because the latter can be very easily broken up into small fragments in mastication.

Preserved Foods.—But few points concerning preserved foods need be mentioned here. In the first place, as is well known, all kinds of preserved foods, but particularly meats, occasionally undergo some degree of decomposition, and this more especially occurs when the containers in which they are purchased have been opened and the food has been exposed to the air for some time before it is eaten. Preserved foods unless preserved by chemicals, often more readily undergo decomposition when the opportunity for bacterial invasion is given than do fresh foods; it is, therefore, quite true, as is commonly supposed, that they should be eaten reasonably quickly after they are opened, or not at all. It is improbable that there is any truth in the common belief that, if left in the can, some specially toxic substance forms. It is more likely that the whole matter is merely a question of bacterial invasion.

Nearly all the preserved foods bought on the market contain some form of antiseptic or chemical preservative. Whatever view may be taken about the use of these substances in small amounts by normal persons, I think that there can be no rational doubt that most of them are irritants and tissue-poisons when taken in considerable amounts; therefore, when one is especially shielding the digestive, the metabolic, or the excretory organs, even from very slight irritants, I think the patient should be instructed to avoid any foods that are preserved by means of chemicals.

Those foods that are preserved by such domestic measures as the use of sugar-solutions, salt, smoking, etc., are, as a rule, less digestible than the fresh foods; for delicate digestive tracts they are, therefore, less suitable, although in varying degree. Salted and smoked meats are usually somewhat toughened by the process of preserving, and the large amount of salt contained in the former may damage digestion, metabolism, or excretion. On the other hand, preserved vegetables and fruits are at times, through the prolonged boiling to which they are subjected, often made more digestible than they were when fresh, providing large amounts of sugar are not used in preparing them.

ARTIFICIALLY PREPARED FOODS AND RECTAL ALIMENTATION

There are also certain points that need mentioning in regard to the nourishment of patients when the normal food-articles, prepared in the normal way, cannot be taken in sufficient amount, or when they cannot be taken in proper amount by the normal channel, that is, by the mouth. If the trouble is not prolonged and is not extremely pronounced,—and this is ordinarily true in acute febrile diseases and in most other transitory affections,—one does wisely to be content, for aggressiveness is usually harmful in such circumstances. Often, however, in both acute and chronic disorders, the digestive tract is so rebellious that the lack of food becomes a dangerous factor and artificial methods of feeding are demanded, and when obstructions are present high up in the alimentary canal, they often make such methods requisite.

If the difficulty is chiefly in the character of the food, artificial methods of preparation will, as a rule, largely overcome it. For example, the untoward changes that some natural proteins, such as the casein of milk, may undergo in digestion can be somewhat modified, as is done by adding an alkali or a cereal to milk, to prevent the formation of dense curds; or the chemical character of the food itself may be altered artificially, as is done by skimming milk, by removing the yolk of eggs, or adding an acid, such as lemon-juice, to egg-albumen water. The latter measure makes the albumin more acceptable to the palate and more digestible, because part of it forms an acid albuminate.

Especially digestible forms of protein, freed from the more indigestible forms, may also be obtained by domestic means or be bought on the market. Beef-juice and well-made beef-tea and broths contain a small amount of soluble protein, while the insoluble part has been discarded. In some of the market-preparations soluble protein is present in solution; in others, in dried form. In still other instances it is the method of preparing the protein, rather than its natural solubility, that makes it useful. For instance, in some proprietary preparations the protein has been predigested to albumoses and peptones; in others, such as some of the casein preparations, it is in the form of a chemical combination with some salt, this combination, in some instances, adding to its digestibility. Predigested forms of protein may also be prepared at home, as in peptonizing milk. It should be remembered that most fluid preparations of protein, whether made at home or purchased as such, contain a very small amount of protein, as a rule—decidedly less than 5 per cent., and most of them not more than 2 or 3 per cent.; and, except for milk, most of them contain very little else that has much actual food-value. Therefore, most of them would have to be used in impossibly large amounts if they alone were to be depended upon to meet the food-demand. Absolute rest in bed so largely reduces the requirement of food that such preparations may properly be used for a short time

as the sole nourishment for patients that are entirely at rest, in case other foods are taken with difficulty. Even in such cases, however, if their use is prolonged, and in all cases, if the patient works or exercises, it very soon becomes evident that they are insufficient.

Some of the fluid preparations on the market are reinforced by the addition of albumoses and peptones, and this increases their fuel-value. Either liquid or solid preparations of albumoses and peptones, however, can usually be taken in but small amount; otherwise gastric disturbance or, more commonly, diarrhea occurs. The dry preparations of native proteins that one purchases have often much fuel-value, because many of them are nearly pure protein; but they often quickly become distasteful. It must also be remembered that when diluted to a suitable form, the actual amount taken at one feeding is really of small fuel-value. Unfortunately, most of the artificial food-preparations, whether of protein or of carbohydrate, are likely soon to arouse repugnance. This difficulty may, to some extent, be overcome by frequently varying the special preparation in use.

Rather more important than protein preparations, from the standpoint of digestibility, as well as of fuel-value, are the artificial carbohydrate preparations that are obtainable on the market. Unfortunately, it is more difficult to make many of the most digestible of these palatable for long use, and also more difficult to find a sufficient variety. In cases that have not very severe disturbance, however,—and these constitute the great majority,—home-prepared cereals that have become partly fluid and more or less dextrinized by prolonged heating and that have been carefully strained are accepted by the digestive organs, as are toast, pulled bread, zwieback, bread-crust, and thoroughly baked crackers. The latter food-articles have, through the action of dry heat, gone through changes similar to those produced in the cereal preparations by moist heat. These various home-made special forms of carbohydrate are our standby in cases of starch indigestion.

Likewise important in occasional cases, because they are sometimes well taken when other preparations cause gastric or intestinal irritation, are gruels that have been quite thoroughly dextrinized with diastatic ferments. These are usually not attractive to the palate, but sometimes, especially when they are slightly but agreeably flavored, they are retained by the stomach even when albumin-water is rejected; and their fuel-value can at times be made equal to or greater than that of milk, although they are still, when well dextrinized, entirely fluid.

In regard to the proprietary foods on the market, it is very important to remember that there has been prevalent a very grossly, indeed, a dangerously, exaggerated idea of their value. Recent precise investigations of their actual food-value have shown that the liquid preparations have at most ordinarily a value about equal to milk, and when it is considered that the daily amount of them that can be employed is rarely as much as three or four ounces, it becomes

clear that they can furnish at best only a small fraction of the quantity demanded by any patient. As to the dry preparations, similar statements hold good, for only small amounts of them are really administered in the diluted form in which they must be given. This is equally true of the dry protein and the dry carbohydrate preparations. Also the liquid preparations contain alcohol in amounts that make their use in any conditions very undesirable, and large amounts, even if it were possible to use large amounts, would often be highly undesirable. The limit of their value in dietetics is to add slight increments to the diet in difficult cases. My own use of them has been very limited indeed, and constantly grows less because I do not meet with circumstances that render it impossible to employ home-made preparations or advisable to use the proprietary preparations, and the home-made preparations may also be made more palatable, are commonly more nutritious, and vastly cheaper; and I have strong objections to encouraging the pernicious and dangerous methods that have been employed in exploiting most of the proprietary foods, when I can meet the indications quite as well or better by other means. It should especially be remembered that the so-called beef or meat "juice" or "extracts" that are on the market are almost wholly valueless as foods.

The market preparations of predigested carbohydrates can sometimes be used in small amounts. Most of them consist largely of maltose, however, and most are more or less sweet in taste. For the latter reason patients often weary of them quickly or they produce nausea if taken in large amount. Large quantities of maltose likewise tend to produce diarrhea. Dextrins, on the contrary, usually tend to allay irritation and to check irritability of the bowels. Though some portions of the dextrin are extremely indigestible and may produce diarrhea, in which case there are often rather curious small, light-colored, gummy masses in the stools, composed of dextrinous material and other substances.

Not only are most fats themselves practically not at all digested until they reach the intestine, but most artificial preparations of fat are soon much altered in the stomach. Probably largely as a consequence of these facts there is relatively little success to be obtained through the use of artificial preparations of fats, as compared with natural forms, such as cream, egg-yolk, olive oil, and butter. Emulsions, however, such as cod-liver oil emulsion, are much better borne than non-emulsified fats. Natural emulsions, chiefly cream or rich milk, are usually quite as acceptable to the digestion, and because they are more palatable they can be taken in larger amounts.

There is a point that needs emphasis in connection with the use of predigested foods: there is too ready a tendency, in case they relieve the symptoms that at the moment arouse anxiety, to prolong their administration indefinitely, and to overlook the fact that this may do harm. It has been abundantly shown by animal experiments that the prolonged use of foods that are so bland as to require little or no work of the digestive organs is harmful; and clinical experience

has convincingly demonstrated that this is true of human subjects also. There is no doubt that the prolonged inaction of the digestive organs that results from the continued use of predigested food may so reduce the functional capacity of these organs that a long and carefully graduated course of dieting is often required to permit them to regain their previous powers. It is probable, also, that the powers of assimilation suffer with those of digestion, for functions work in unison, and one normally stimulates another. The taste or even the sight of food is known to set the stomach at work preparing for its prospective labors even before the food has reached it, and similar occurrences take place in the further course of digestion, and the chain is certainly not broken when the food passes the walls of the intestine. Predigestion has value, but it is an artificial measure, and its use should be limited to periods in which it is necessary.

It has unquestionably been used much more frequently than there has been any occasion for it. It is not uncommonly looked upon as a dietetic cure-all, whereas it is really seldom demanded, and sometimes it does not at all do what is wanted. Most frequently it is employed in using milk, and with milk the commonest cause of trouble lies in the fats, and peptic or tryptic predigestion does not aid this at all, while removing the fats does. When the trouble is with the casein, it can usually be overcome by dilution or by the other simple measures mentioned later, or by using another simple food. In uunsual instances predigestion is valuable, but I find comparatively little occasion for it.

Buttermilk and various artificial kinds of sour milk have come into such prominence lately with both the public and profession that their use has become somewhat of a cult, and they need some special discussion. They are generally employed with adults almost exclusively on the ground that the bacteria which they contain will overgrow those germs which cause fermentation and putrefaction in the digestive canal. There is no doubt that they accomplish this at times in some degree, for it has even been shown that pathogenic forms of bacteria (typhoid bacilli) may disappear from the intestinal tract after the use of yoghurt, for example, when these bacteria had long been present previously, and likewise these bacteria have been shown to be at times, at least, killed in milk itself in the course of its change to buttermilk. The latter occurrence is due in large part to the considerable amount of lactic acid formed; the former also is perhaps largely dependent upon this fact. The effects of these sour milks are, however, somewhat complex, and due to more things than the overgrowth of bacteria and the formation of lactic acid. They at times certainly do good because, I think, of the following reasons: the protein in them is altered, and for most persons is made more digestible; the milk-sugar is largely or completely changed into other substances (lactic acid, alcohol, etc.), and this helps to relieve digestive trouble with some persons; with real buttermilk the fat is removed, and some of the artificial preparations have more or less of the fat removed, and this does away,

in many instances, with the chief cause of digestive disorder. Furthermore, most of them have slightly laxative properties, which is often an advantage, particularly when the patient, as is frequently the case, is confined to a very plain diet, which is likely to be constipating. I have not been able to convince myself that their direct influence upon bacterial growth has much to do with their effects in most cases of fermentation and putrefaction in the intestine, for the results with other diet that agrees equally well appear generally to be equally good; at times, however, they seemingly do overcome the trouble by their own influence, and probably in such cases this is sometimes, the result of their action upon the intestinal bacteria. At any rate, they are certainly often valuable as readily digestible foods, and when carefully made from good milk, they have a great advantage over ordinary milks in that they are relatively free from the harmful forms of bacteria that occur in enormous numbers in much of the market milk, and that cause a great deal of the disturbance that is commonly attributed to milk. On the other hand, these sour milks are very distasteful to many people, and they do not agree well with some persons apparently chiefly because of their high content of lactic acid. Also it is to be remembered that they may carry very troublesome infections if made from poor milk or if badly kept. I have seen very serious disturbances from market buttermilks. And, finally, it is to be noted that they are most commonly used in conditions that are due to errors in diet, and when the indulgence that causes the trouble is still permitted, and some form of sour milk is merely added as a sort of cure-all, it is likely simply to add trouble to an already overburdened digestion.

Subcutaneous Feeding.—When artificial methods of preparing foods do not meet the difficulties, or when obstructive disease prevents the access of food to the stomach or the intestine, other avenues must be used to introduce as much as possible of what is needed. The only other avenues available without formal surgical interference are the lower bowel and the subcutaneous tissues. The latter often serve nowadays, for the introduction of water, but it is, at best, trying to the patient, and dangerous, unless great care is used, to attempt to introduce other solids than salts in this way; and, in spite of the many attempts to make it clinically useful, subcutaneous feeding remains in the experimental stage, and it is still doubtful whether it will ever be of any real value.

Rectal alimentation, on the contrary, can be very easily carried out and is in constant use; but its value is usually greatly overrated. Many investigations in regard to its usefulness, a number of which I have myself made, have shown that the amount of solid food absorbed by this channel is, as a rule, small—much too small, indeed, to permit of maintaining a nutritive equilibrium. Usually not more than one-third of the total amount required can be absorbed, and very frequently, indeed, much less than this. Not only is the amount absorbed small, but the total bulk that can be given per rectum is

very limited. Hence the actual amount that reaches the tissues is quite insufficient. Furthermore, the bowel is likely to grow irritable quickly, and it then rejects the enemata before any absorption can occur. Nevertheless, some food is absorbed from the lower bowel. When none can be taken by the mouth, one cannot long depend upon rectal feeding, but some food is better than entire starvation. In some cases, also, rectal alimentation can be used with good results to reinforce insufficient alimentation by the mouth.

The technic of the use of nutritive enemas cannot properly be discussed in this article. It may be mentioned, however, that to avoid irritating the bowel the nutritive enemas should not be given more than four times in the twenty-four hours (better, not more than two or three times); and that the bowel should be regularly cleansed with simple enemas. Non-irritating food should be used, and the food should usually be partially predigested, but not considerably so, for considerable amounts of albumoses and peptones will irritate the bowel. Eggs, milk, and various preparations of soluble protein, together with a moderate amount of some preparation of sugar, are usually the chief dependence. Probably dextrinized carbohydrates could, with profit, be used much more frequently than they are for this purpose.

CERTAIN GENERAL CONSIDERATIONS

In arranging a diet one should, in all cases, keep in mind certain other facts that are susceptible of accurate proof, as well as certain general facts that are largely derived from experience, rather than from established laws. The latter are partly dependent upon peculiarities of the organism that have no evident basis, but they are partly due to the mere frailties of human kind.

In the first place, in cases that are at all difficult, simplicity in the diet is one of the most important things—more important, perhaps, in the general run of cases than any other one point. Its value lies chiefly in two directions: First, the patient will often adhere more closely to his diet if it is made severe at first, but the prospect of a frequent increase in the variety of foods is given him. More important than this, a disturbed digestion and metabolism can deal much more easily with a small number of food-articles than with a large variety.

The mere fact that food-articles contain a certain amount of protein, carbohydrate, fat, salts, and water is but a small part of the knowledge that we should have of their composition and their effect upon digestion and metabolism. We know already many minor differences, and there are many more to be learned. Even though these differences may have little or no influence when only a small variety of bland foods is given, each difference in detail complicates the task that the digestive organs and the tissues must complete in making use of the food. A weary brain may do a few simple things well, but will do a multiplicity of simple things ill; likewise, a weary digestion or metabolism may deal very readily with a few simple foods,

but be undone by a great variety, even though all are individually suitable.

A very large proportion of gourmands, then, suffer not so much because they eat too much food, as because they take a diet that is extremely varied and elaborate, particularly in the manner of its preparation. On the other hand, it must always be remembered that the variety in food-articles must, when possible, be made reasonably large; otherwise the appetite soon fails, and the patient becomes undernourished. Great simplicity, therefore, cannot ordinarily be wisely continued for any considerable length of time, unless circumstances force this upon one.

In many cases of acute digestive disturbance temporary entire withdrawal of food is the most important point in the whole treatment. This is but too rarely appreciated and acted upon. Persistent vomiting, of course, demands it, but it is important in much less violent disturbance of the stomach and in great irritability of the intestines, especially when foul bowel movements show that excessive putrefaction is going on. The extreme value, in some cases, of temporary starvation is becoming widely recognized in dealing with young children, but it needs to be even more generally used with them in proper instances; and with adults its great usefulness is much less extensively appreciated. Just as it gives the gastro-intestinal tract opportunity to empty itself of irritating material and to rest for a time, so does it permit of the excretion of toxic material in toxemias, and provide some rest for the organs of metabolism and excretion. Consequently, it is frequently useful in some toxic states due to disease of the liver or kidneys, as well as in gastro-intestinal disturbance.

In ordering complete or almost complete withdrawal of food, however, one must remember that he frequently thereby takes the patient's very life into his hands. Consequently he must do it for only a very brief period—usually a day or two days, at most, of complete starvation—and it should be done only with intelligent purpose. I know of no more dangerous enthusiasm than that which has recently arisen among a few modern followers of the doctrine of starvation in treating disease; and while temporary starvation is more frequently important in infants than in adults, it needs to be used with the greatest care in young children, for they succumb to starvation much more quickly than older persons.

A point directly connected with this is the effect of the bulk taken at one meal. It is a long-established fact that irritability of the stomach or intestine usually necessitates small meals, the proper total amount being then secured, as far as is possible, by frequent feedings. Large bulk usually means, in such cases, that the stomach expels the food quickly by vomiting or by driving it on into the intestine before it has been properly prepared for intestinal digestion. Diarrhea is often caused or prolonged in both acute and chronic cases by taking unduly large meals. In some instances, however, large meals taken at wide intervals are better borne by a disturbed digestive tract than

are small or moderate sized meals that are taken at more frequent intervals; but this is relatively uncommon.

One factor, I am sure, in producing much of the gastro-intestinal disturbance in America is the very large breakfast habitually taken by many persons. Although the interval since the last meal is a long one, there has, as a rule, been almost no work or exercise in this interval, and therefore a large meal is not usually demanded. At any rate, as a practical fact, a large number of persons have better digestion when a rather small breakfast is taken, and I have repeatedly known this to relieve chronic digestive disorders.

On the other hand, it is common, among young women especially, and particularly among those who work for their living or who are much pampered, to take little or no breakfast, and this is a common cause of poor general nutrition, headaches, a chlorotic state of the blood, and other disorders.

Similarly important is the fact that many articles of food that are, for people in general, digestible and nutritious, cannot be taken by some individuals without ill effects, owing to some more or less obscure idiosyncrasy. Milk, for example, which, with the great mass of humanity, is very easily digested and is more nearly a complete nutriment than any other single food-article, is sometimes a poor form of nourishment. This is far less frequently the case than many persons believe. Most commonly, the difficulty in taking milk is dependent upon repugnance for it, erroneous preconception, bacterial infection of the milk, or factors that can readily be overcome by simple methods of preparation. In such cases flavoring the milk with a little salt, tea, coffee, cocoa, or some preparation of alcohol will often overcome this repugnance; it will also frequently make the milk digest better, probably because it does make it more palatable. Adding gruel or an alkali to milk will often modify the curd, and will frequently overcome the digestive disturbance that it causes, with adults as well as with children. The fat is very commonly at fault, and in that case skimmed milk will often be well taken. Very frequently, indeed, especially when there is already delicacy of digestion and hence susceptibility to infection, heating the milk will stop any gastric symptoms, intestinal fermentation, or diarrhea that it produces—partly through the chemical and physical changes that heating produces in the milk, but much more because it kills the bacteria in which most market milk abounds. The latter fact is now pretty generally recognized in treating young children, but it needs to be far more widely appreciated in the care of older children and adults than it yet is. In spite of all these measures, however, milk is, in a small number of cases, extremely repulsive, or it persistently causes untoward symptoms, without any evident good reason. In such cases it is not a good form of nourishment, and something else must be given in the place of it.

Similar statements are true of eggs. Instances are not uncommon, especially in young children, in which eggs cause more or less severe

disturbance, particularly of the stomach, even though taken raw or but slightly cooked, and even though the manner of preparation may have so far disguised the taste of the eggs that the patient did not know that he had eaten them. This is generally due to the yolk, and caused by the fat in it. Such patients can usually take egg-albumen with great freedom. In some curious cases, however, it is due to the albumen.

Very many persons believe that they have an idiosyncrasy toward fish and other sea-foods. These foods not infrequently cause digestive disturbances and signs of general poisoning, but while these are at times due to a peculiarity of the individual, they are much more commonly due to the fact that sea-foods are very likely to undergo bacterial changes before they are eaten.

There are, however, other real and important idiosyncrasies, such as the curious toxic symptoms that may result from eating strawberries and some other fruits, and the milder symptoms that seem to be caused in individuals by many other foods. Such peculiarities, if they seem to be real, should not, except for very especial reasons, be fought, but should be yielded to.

Some of these idiosyncrasies are purely of appetite, but even then they often influence the choice of foods. Special food-articles may be very repulsive, or there may be a repugnance to a whole class of foods, such as meats or fats. This in some instances constitutes almost a symptom of certain special diseases. Sometimes delicate methods of preparation will overcome such feelings, but if they do not, and the repugnance is not mere fancy, no good can be accomplished, as a rule, by attempting to do away with such idiosyncrasies by force. Often, with the sick, they disappear as health returns. If one desires actual scientific demonstration of the real effect of such peculiarities, one finds it in the experimental work of Pawlow on the influence of psychic factors upon digestion.

The appetite also often has to be pampered for other reasons, by fair means or foul. One sometimes mildly deceives those that are habitually heavy eaters, and insist upon filling their stomachs, by permitting them to eat freely of foods that have a large bulk, but only a small fuel-value. In obesity, for instance, and in some digestive disorders that permit of this, the sensuous gratification that results from this measure frequently leads the self-indulgent patient to persist in proper treatment when otherwise he would rebel. The same purpose may often be accomplished in another way: one may grant some degree of freedom in the amount of food, but exclude the use of condiments and sauces and of water at meals. The patient then usually reduces his intake unconsciously. When, on the other hand, the appetite is so depressed that too little food is taken, one may often, if this is suitable for the digestion in the individual case, increase the intake by giving the food in as concentrated a form as is compatible with attractiveness; but the appetite should especially be stimulated by delicate methods of preparing and serving the food, by using con-

diments, or by various other devices, such as beginning the meal with a small amount of some light, but stimulating and agreeably flavored food-article, like bouillon or fruit. Mere insistence upon the patient's taking a much larger quantity of food than his appetite calls for is a very unsuccessful and ill-judged way of treating malnutrition from any cause, unless it be hysteria, insanity, or the anorexia that may develop in severe emaciation and inanition.

The appetite needs to be carefully considered, also, when one establishes regulations that differ largely from normal customs or the patient's habits. In such circumstances, particularly if the restrictions imposed are pretty narrow, the food-articles ordered readily become repulsive, and the patient, then, if he adheres to his diet, may become ill-nourished, merely because he can take only a small amount of what is permitted him. For this reason one needs, in cases that are at all protracted, to be careful to restrict the diet only so far and so long as is essential, especially if there is danger, already, of malnutrition. Very often, indeed, one's chief duty is to enlarge the diet, because the patient is suffering from the effects of a restriction that has been imposed upon him, or that his own overfearfulness has led him into. In fact, one of the most common and most serious errors made in dietetics is to advise, or to permit the patient to carry out, too great a restriction in the amount and variety of food, and thereby to produce more or less serious malnutrition that is very often worse than the original disorder.

There is another fact that is dependent partly upon the frailties of the patient, and partly upon the carelessness of the physician: Diets are very frequently adhered to but loosely. This is extremely difficult to control, in many instances, in family practice, and hence patients that need rigid regulation of their diet often do much better in institutions than at home. This trouble, however, can be largely overcome if one is absolutely definite and specific in stating the constituents of the diet, the character of the separate meals, and the time at which they are to be eaten; and, as far as possible, in regulating the amount of the different food-articles permitted. All these statements, in all cases in which the diet is of decided importance, should be written out in detail. Furthermore, the patient should be required to keep a record of his meals, and this should be carefully supervised and controlled. When a list stares him in the face, he cannot plead a lapse of memory; and specific statements, together with a sense of being frequently under detailed inspection, serve as a very effectual control in most instances.

When one comes to the actual choice of the diet in individual cases, the rigidity of the restrictions necessary, next to the general character of the diet, is a point to be quickly settled. There may be, for example, merely a mild disturbance of digestion or a moderate degree of malnutrition; and in such instances the only necessity may be, on the one hand, to exclude a few articles of diet, or, on the other, to increase the amount of the articles taken or to enlarge the choice.

Even such simple measures, however, should be clearly and definitely established. At the other extreme are those cases, such as acute infectious diseases and severe gastro-intestinal disturbances, in which it is necessary to cut down the total amount to a low point and to give only very bland foods; or those cases in which the main point is to exclude very rigidly a considerable number of food-articles belonging to a special class—as is done in many forms of gastro-intestinal disorder, in nephritis, in diabetes, and in various other conditions. When such rigid regulations are enforced, it is necessary to see to it that the times of taking food and the amounts to be used are clearly determined and closely adhered to. Irregularity in the times of taking food or in the amounts used is nearly always harmful, even to normal persons; and it is particularly harmful when disease and very abnormal conditions of diet tend to make the total intake insufficient.

Besides this, when the diet is made very one-sided or otherwise of unusual character, it is extremely important, for the direct purpose for which the diet is used, to oversee carefully the amounts that should be taken, and to determine that the patient follows the directions accurately. Unless he is kept under careful control, he usually will not do this himself, partly because of carelessness and partly because he frequently does not appreciate, in such circumstances, how much or how little total food he is actually taking. For example, if nearly all the carbohydrate is excluded from the diet, it often means that at least half the total food is excluded. It requires some knowledge and ingenuity to furnish substitutes for this, and the patient may readily emaciate unless the character and the amount of the food-articles that he takes are carefully determined for him, simply because he himself has not the knowledge or the skill required to find a sufficient number of substitutes.

The more strict the exclusions, therefore, and the more odd and unusual they make the diet, the more carefully should one suggest substitutes and control the quantity taken. In cases in which very strict diet is ordered it is of clinical importance to calculate in calories the fuel-value of the food that one is ordering. There is no other way to determine whether sufficient food is being given, except guess-work and experience. If simple guess-work is used, one flounders about and reaches a decision that may be either correct, or, more probably, very erroneous. If the guessing is aided by considerable experience, it may be more or less close; but otherwise it is hit or miss, and everything is left to the patient's appetite, which may or may not lead him to take what he needs.

It would be unnecessary labor to attempt to calculate the fuel-value of all diets. In a very large proportion of instances careful weight-records are sufficient guides as to the progress of general nutrition, and one allows the appetite, reasonably controlled, to determine how much of what one permits him to use the patient will eat. In most instances this works successfully; but with diets that are very restricted in total value or with those that are very odd in their character,

a calculation of the calories in the food tells one very plainly whether one's orders approach closely to the demand, or whether one is giving a dangerously small amount or is, on the other hand, perhaps, carefully treating a fat man by ordering twice as much food as he needs.

In instances in which an extremely simple and limited diet is used, as in acute febrile diseases, it is a very easy matter to determine the number of calories in the food; and after a very little practice it can, in such cases, be reckoned in one's head. In cases in which a greater variety is being given, it is somewhat more trouble; but a little practice makes it comparatively easy, even in such instances. One needs to have an approximately accurate idea of the weight of the usual domestic measures for solid foods. One can, after a little, gain a knowledge of many details in this connection by keeping at hand an ordinary domestic scale and weighing the usual portions of various food-articles as they appear on the table. With the knowledge thus acquired any one who is interested in accurate and careful dietetics is soon capable of ordering a diet in a way that will not oblige his patient to weigh his food, but will still approach approximately to the amounts that he desires his patient to have. In a certain number of cases very great accuracy is especially important. In such instances the patient needs to be under the care of a nurse, or to be in an institution, where the amount given him at each meal can be weighed and reliably determined, although he can sometimes be trained to do this himself.

A list of many of the most important foods, in relation to their fuel-value per pound and to the amount of protein, fat, carbohydrate, and water that they contain, follows. The figures in the list are taken from the valuable Bulletin No. 28, United States Department of Agriculture, by Atwater and Woods. In this bulletin one may find a most useful collection of data concerning the fuel-value and the protein, fat, carbohydrate, water, salt, and refuse-content of a large number of American food-articles, and in various other bulletins of the same department are many similar facts, as well as figures concerning the cost of food-articles.

The values that I have chosen are those for the edible portion in all instances, except when marked "as purchased," and they are chiefly averages; though, with the meats, I have introduced the figures for a number of cuts, in order to show the variations in these different cuts. Under "ribs of beef" I have given also an illustrative example of the influence of leanness or fatness of the individual cuts upon their protein and fat-content and upon their fuel-value. It will be noticed that the protein-content of meats varies moderately, while the fat-content shows wide differences, and the latter fact is the chief cause of the very striking differences in fuel-value. For the purpose of calculating from this list the fuel-value of the meat in any diet one should, ordinarily, use the figures for ribs, sirloin, or tenderlion of beef; for leg or loin of mutton, etc.—in other words, the parts chiefly used in a diet-list.

This list of figures, besides its occasional usefulness in reckoning the value of a diet, shows many points that are of importance in dietetics in other ways. For instance, when one needs largely to eliminate one form of food-substance, or to increase another form; or when one is attempting to increase the intake of highly nutritious foods, or, on the other hand, to give much bulk and but moderate fuel-value, one may reach much greater accuracy by referring to such figures. Besides the variations in the different kinds and cuts of meats, which have been already mentioned, note, for example, the low fat-content and the consequent low fuel-value of chicken and most fish, as compared with most cuts of beef; the important fuel-value of cheese, due to its content of protein and fat; the value of honey and molasses, due to their high carbohydrate content, and of many desserts and cakes, due chiefly to carbohydrate and fat; the extremely high fuel-value of pure or nearly pure fats, such as butter, lard, and some cuts of pork; the very decided importance of many fruits as fuel; the high protein-content of peas, beans, and lentils, as compared with other vegetables; the very low food-value of most soups; the very low protein-content of most vegetables, and the low fuel-value of the latter as they are purchased or served—the low fuel-values in these last three instances being due to the high water-content and the almost complete absence of fat. Also note the influence of the absorption of water in cooking upon the actual fuel-value as foods appear on the table—a point seen by comparing the real fuel-value of rice, when boiled, with its theoretic value, when dry; and, finally, the difference that there may be in the fuel-value of the same weight of different table-preparations of the same food-article, this point being shown to an exaggerated degree by the difference between boiled potatoes and potato-chips, the latter having by weight over five times the value of the former, through the addition of fat and the loss of water in the course of their preparation.

FOOD MATERIALS

Animal Food	Water	Protein	Fat	Carbohydrate	Fuel-value per Pound
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories*
Beef, Fresh:					
Brisket, medium fat	47.4	14.6	37.2	..	1,840
Chuck, all analyses	67.3	19.1	12.6	..	885
Loin, all analyses	61.2	18.3	19.5	..	1,160
Tenderloin, all analyses, as purchased	59.2	15.6	24.4	..	1,320
Ribs, very lean	72.6	21.1	5.6	..	630
Ribs, medium fat	55.4	16.9	26.8	..	1,445
Ribs, fat	48.1	15.4	35.8	..	1,795
Ribs, all analyses	56.6	17.1	25.5	..	1,395
Round, all analyses	68.5	20.4	10.0	..	800
Rump, all analyses	57.7	17.6	23.8	..	1,330
Forequarter, all analyses	61.5	17.5	20.2	..	1,180

FOOD MATERIALS.—(*Continued.*)

Animal Food	Water	Protein	Fat	Carbohydrate	Fuel-value per Pound
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories*
BEEF, FRESH—(*Continued*)					
Side, not including tallow:					
Native	57.1	17.2	24.9	..	1,370
Colorado	63.4	18.0	17.7	..	1,080
Side, all analyses	61.7	17.8	19.6	..	1,155
Sweetbreads, as purchased	70.9	15.4	12.1	..	795
Tongue, whole, as purchased	51.3	21.5	23.2	..	1,380
Corned beef, all analyses	54.5	15.6	25.5	..	1,365
Dried, salted, and smoked, as purchased	50.8	31.8	6.8	0.6	890
VEAL:					
Breast, all analyses	67.5	19.3	12.2	..	875
Leg, all analyses	72.4	20.6	5.9	..	630
Leg, cutlets	68.3	20.8	9.9	..	805
Loin, all analyses	69.2	19.5	10.2	..	795
Shoulder	68.3	19.9	10.7	..	820
Kidney, as purchased	74.7	16.6	7.4	..	625
Liver, as purchased	73.1	20.4	5.3	..	605
Leg, hind, all analyses	58.6	17.8	22.6	..	1,285
Loin, without kidney and tallow, medium fat	53.1	17.6	28.3	..	1,520
MUTTON:					
Leg, hind, all analyses	63.2	18.3	17.5	..	1,080
Loin, without kidney and tallow, all analyses	47.6	15.2	36.4	..	1,820
Shoulder, all analyses	60.0	17.1	22.0	..	1,245
PORK:					
Loin, all analyses	50.5	16.1	32.5	..	1,670
Ham, fat, as purchased	9.1	2.7	88.0	..	3,765
Ham, fresh	62.8	18.5	17.7	..	1,090
Ham, smoked, boiled, no bone, as purchased	39.2	18.2	37.0	..	1,900
Shoulder, fresh	54.3	15.5	29.4	..	1,530
PORK, SALTED AND PICKLED:					
Dry salted backs	17.3	7.2	72.7	..	3,200
Salt pork, clear fat, as purchased	7.3	1.8	87.2	..	3,715
Salt pork, lean ends	19.9	7.3	67.1	..	2,965
Bacon, smoked, all analyses	19.3	10.5	65.5	..	2,960
SAUSAGE:					
Arles	17.2	24.9	50.6	..	2,600
Bologna	55.2	18.0	19.7	..	1,165
Bologna, cervelat, imported, as purchased	20.6	25.9	41.2	4.8	2,310
Frankfort, as purchased	55.5	21.7	18.8	0.4	1,205
Pork, as purchased	38.7	12.8	45.4	0.8	2,170
SOUPS:					
Asparagus, cream of, as purchased	87.4	2.5	3.2	5.5	285
Bouillon, as purchased	96.5	2.0	0.1	0.2	45
Celery, cream of, as purchased	88.6	2.1	2.8	5.0	250
Chicken, as purchased	93.8	3.6	0.1	1.5	100
Chicken gumbo, as purchased	89.2	3.8	0.9	4.7	200
Mock turtle	89.8	5.2	0.9	2.8	185
Ox-tail, as purchased	87.8	3.8	0.5	4.2	170
Pea, as purchased	85.1	4.2	0.5	9.0	265
Tomato, as purchased	90.0	1.8	1.1	5.6	185
Turtle, green, as purchased	86.6	6.1	1.9	3.9	270
Vegetable, as purchased	95.7	2.9	..	0.5	65
POULTRY AND GAME, FRESH:					
Chicken	74.2	22.8	1.8	..	500
Fowl	65.2	10.3	14.4	..	965

Food Materials.—(*Continued.*)

Animal Food	Water	Protein	Fat	Carbohydrate	Fuel-value per Pound
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories*
Poultry and Game, Fresh—(*Continued*)					
Goose	42.3	13.0	43.9	..	2,095
Turkey	55.5	20.6	22.9	..	1,350
Chicken, gizzard, as purchased	72.5	24.7	1.4	..	520
Chicken, heart, as purchased	72.0	21.1	5.5	..	625
Chicken, liver, as purchased	69.3	22.4	4.2	2.4	635
Fish:					
Bass, black, whole	76.7	20.4	1.7	..	450
Bass, sea, whole	79.3	18.8	0.5	..	370
Bluefish, entrails removed	78.5	19.0	1.2	..	405
Butterfish, whole	70.0	17.8	11.0	..	795
Cod, whole	82.6	15.8	0.4	..	310
Eels, salt-water, dressed	71.6	18.3	9.1	..	725
Flounder, whole	84.2	13.9	0.6	..	285
Haddock, entrails removed	81.7	16.8	0.3	..	325
Halibut, steaks or sections	75.4	18.3	5.2	..	560
Herring, whole	72.5	18.9	7.1	..	650
Mackerel, whole	73.4	18.2	7.1	..	640
Perch, white, whole	75.7	19.1	4.0	..	525
Salmon, whole	65.2	20.6	12.8	..	925
Shad, whole	70.6	18.6	9.5	..	745
Shad-roe, as purchased	71.2	20.9	3.8	2.6	600
Smelt, whole	79.2	17.3	1.8	..	400
Spanish mackerel, whole	68.1	21.0	9.4	..	790
Sturgeon, anterior sections	78.7	18.0	1.9	..	415
Trout, brook, whole	77.8	18.9	2.1	..	440
Weakfish, whole	79.0	17.4	2.4	..	425
Fish, Preserved and Canned:					
Halibut, smoked	49.4	20.6	15.0	..	1,015
Herring, smoked, entrails removed	34.6	36.4	15.8	..	1,345
Mackerel, salt, entrails removed	42.2	22.0	22.6	..	1,360
Salmon, canned	64.9	20.7	10.8	1.2	865
Sardines, canned	56.4	25.3	12.7	..	1,010
Sturgeon, dried, Russian	50.6	32.2	9.6	..	1,005
Sturgeon, caviare, pressed, Russian, as purchased	38.1	30.0	19.7	7.6	1,530
Shellfish, Etc., Fresh:					
Clams, long, in shell	85.8	8.6	1.0	2.0	240
Crabs, hard, whole	77.1	16.6	2.0	1.2	415
Lobster, whole	79.2	16.4	1.8	0.4	390
Oysters in shell	86.9	6.2	1.2	3.7	230
Scallops, as purchased	80.3	14.8	0.1	3.4	345
Terrapin	74.5	21.0	3.5	..	540
Turtle, green, whole	79.8	18.5	0.5	..	365
Eggs:					
Hens' eggs	73.5	14.9	10.6	..	725
Dairy Products, Etc.:					
Butter	..	..	82.4	..	3,475
Whole milk	87.0	3.3	4.0	5.0	325
Skim milk	90.5	3.4	0.3	5.1	170
Buttermilk	91.0	3.0	0.5	4.8	165
Condensed milk	30.5	8.2	7.1	52.3	1,425
Cream	74.0	2.5	18.5	4.5	910
Cheese:					
American pale	31.6	28.8	36.2	..	2,060
Cheddar	35.6	28.2	32.0	..	1,875

FOOD MATERIALS.—(*Continued.*)

ANIMAL FOOD	WATER	PROTEIN	FAT	CARBOHYDRATE	FUEL-VALUE PER POUND
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories*
DAIRY PRODUCTS, ETC. (CHEESE)—(*Continued*)					
Crown brand	31.4	5.2	58.0	2.2	2,585
Dutch	35.2	37.1	17.7	..	1,435
Brie	60.2	15.9	21.0	1.4	1,210
Limburger	42.1	23.0	29.4	0.4	1,675
Neufchâtel	50.0	18.7	27.4	1.5	1,530
Pineapple	23.0	29.9	38.9	2.6	2,245
Roquefort	39.3	22.6	29.5	1.8	1,700
Swiss	31.4	27.6	34.9	1.3	2,010
Whole milk	33.7	26.0	34.2	2.3	1,965
Skim milk	45.7	31.5	16.4	2.2	1,320
MISCELLANEOUS:					
Gelatin	13.6	84.2	0.1	..	1,570
Animal and other fats, except butter:					
Tallow, refined	..	..	100.0	..	4,220
Lard, refined	..	..	100.0	..	4,220
Cottolene	..	..	100.0	..	4,220
Oleomargarin	0.3	1.3	82.7	..	3,515
VEGETABLE FOOD					
WHEAT FLOURS, MEALS, ETC.:					
Entire wheat flour	12.1	14.2	1.9	70.6	1,660
Graham flour	11.8	13.7	2.2	70.3	1,655
Roller process flour	12.5	11.3	1.1	74.6	1,645
Macaroni and vermicelli	10.8	11.7	1.6	72.9	1,640
Wheatlet	10.4	12.3	1.4	75.0	1,685
White wheat farina	9.7	11.1	1.4	77.6	1,710
OTHER FLOURS, MEALS, ETC.:					
Barley, pearled	10.8	9.3	1.0	77.6	1,660
Buckwheat flour	14.3	6.1	1.0	77.2	1,590
Corn-meal, bolted	12.9	8.9	2.2	75.1	1,655
Corn, hominy	11.9	8.2	0.6	78.9	1,645
Oatmeal	7.2	15.6	7.3	68.0	1,860
Rice	12.4	7.8	0.4	79.0	1,630
Rice, boiled	52.7	5.0	0.1	41.9	875
Rye meal or flour	12.7	7.1	0.9	78.5	1,630
BREAD, CRACKERS, AND PASTRY:					
Bread:					
White	35.4	0.5	1.2	52.8	1,205
Brown	40.0	5.0	2.4	50.7	1,135
Gluten	35.7	11.1	2.4	48.6	1,210
Graham	32.3	8.5	1.8	55.9	1,275
Rye	31.8	10.1	0.7	55.9	1,255
Average, all analyses, of rolls	26.9	9.6	5.2	57.3	1,465
Biscuit	22.9	9.3	13.7	52.6	1,730
Average of all buns	30.5	8.3	7.1	53.2	1,445
Cake:					
Frosted	17.7	6.2	9.4	64.3	1,705
Fruit	16.9	6.2	10.5	64.7	1,760
Gingerbread	16.1	5.4	9.5	64.7	1,705
Sponge	11.6	6.5	9.6	70.3	1,830
Average of all cake	20.4	7.0	8.1	63.4	1,650
Cookies, molasses	5.1	6.5	9.5	76.9	1,950
Crackers:					
Butter	6.9	9.2	13.6	69.4	2,035
Graham	5.0	9.8	13.6	69.7	2,050

FOOD MATERIALS.—(*Continued.*)

VEGETABLE FOOD	WATER	PROTEIN	FAT	CARBOHYDRATE	FUEL-VALUE PER POUND
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Calories*
BREAD, CRACKERS, AND PASTRY (CRACKERS)—(*Continued*)					
Oyster	4.3	11.0	8.8	74.2	1,955
Soda	8.0	10.3	9.4	70.5	1,900
Doughnuts	17.9	6.6	21.0	52.6	2,025
Jumbles	24.8	6.3	15.7	51.9	1,745
Pie:					
Apple	43.2	3.3	9.8	41.7	1,250
Cream	29.4	6.3	8.1	54.9	1,480
Custard	62.4	4.2	6.3	26.1	830
Lemon	47.4	3.6	10.1	37.4	1,190
Mince	42.6	6.5	12.1	37.2	1,325
Squash	64.2	4.4	8.4	21.7	840
Average of all pie	44.8	4.6	9.5	39.6	1,220
Pudding, tapioca	61.8	3.6	3.7	30.0	780
Wafers, vanilla	5.8	6.8	15.7	71.2	2,115
SUGARS:					
Honey, strained	..	..	..	75.1	1,395
Molasses	25.7	2.7	..	68.0	1,315
Sugar, granulated	..	..	..	100.0	1,860
Sugar, maple	..	..	..	82.8	1,540
Syrup, maple	..	..	..	70.1	1,305
STARCHES:					
Tapioca	11.6	0.4	0.3	87.5	1,650
VEGETABLES:					
Artichokes, as purchased	79.5	2.6	0.2	16.7	365
Asparagus, as purchased	94.0	1.8	0.2	3.3	105
Beans:					
Dried, as purchased	13.2	22.3	1.8	59.1	1,590
Lima, dried, as purchased	11.1	15.9	1.8	67.1	1,620
Lima, green, as purchased	68.5	7.1	0.7	22.0	570
String-, as purchased	87.3	2.2	0.4	9.4	235
Beets	87.6	1.6	0.1	9.6	210
Brussels sprouts	88.2	4.7	1.1	4.3	215
Cabbage	90.3	2.1	0.4	5.8	165
Carrots	88.2	1.1	0.4	9.2	210
Cauliflower, head, as purchased	90.8	1.6	0.8	6.0	175
Celery, as purchased	94.4	1.4	0.1	3.0	85
Corn, green (sweet)	81.3	2.8	1.1	14.1	360
Cucumbers	96.0	0.8	0.2	2.5	70
Egg-plant	92.9	1.2	0.3	5.1	130
Greens, as purchased	82.9	3.8	0.9	8.9	275
Leeks	91.8	1.2	0.5	5.8	150
Lentils, as purchased	10.7	26.0	1.5	58.6	1,635
Lettuce	94.0	1.3	0.4	3.3	105
Okra, as purchased	87.4	2.0	0.4	9.5	230
Onions	87.3	1.7	0.4	9.9	235
Parsnips	79.9	1.7	0.6	16.1	355
Peas, dried, as purchased	10.8	24.1	1.1	61.5	1,640
Peas, green	78.1	4.4	0.5	16.1	400
Pickles, cucumber, as purchased	89.0	0.5	0.5	5.4	130
Potatoes, boiled, as purchased	73.7	2.7	0.2	22.3	475
Potato-chips, fried, as purchased	1.8	7.6	35.5	50.6	2,580
Potatoes, raw, as purchased	67.1	1.8	0.1	15.3	325
Potatoes, sweet	69.3	1.8	0.7	27.1	565

FOOD MATERIALS.—(*Continued.*)

VEGETABLE FOOD	WATER	PROTEIN	FAT	CARBOHYDRATE	FUEL-VALUE PER POUND
	Per ct.	*Per*	*Per ct.*	*Per ct.*	*Calories*
VEGETABLES—(*Continued*)					
Pumpkins	93.1	1.0	0.1	5.2	120
Radishes	90.8	1.4	0.1	6.6	155
Rhubarb	94.4	0.6	0.7	3.6	105
Sauerkraut, as purchased	86.3	1.5	0.8	4.4	145
Spinach, as purchased	92.4	2.1	0.5	3.1	120
Squash	86.5	1.6	0.6	10.4	245
Tomato-catsup, as purchased	77.7	2.0	0.4	16.1	355
Tomatoes, as purchased	94.4	0.8	0.4	3.9	105
Turnips	88.9	1.4	0.2	8.7	195
FRUIT, BERRIES, ETC., FRESH:					
Apples	82.0	0.5	0.5	16.6	340
Apricots	85.0	1.1	..	13.4	270
Bananas, yellow	74.1	1.2	0.8	22.9	480
Blackberries, as purchased	88.9	0.9	2.1	7.5	245
Cherries	86.1	1.1	0.8	11.4	265
Cranberries, as purchased	88.5	0.5	0.7	10.1	225
Figs, fresh, as purchased	79.1	1.5	..	18.8	380
Grapes	78.8	1.3	1.7	17.7	425
Lemons	89.3	1.0	0.9	8.3	210
Muskmelons	89.5	0.6	..	9.3	185
Oranges	88.3	0.8	0.6	9.7	220
Pears	83.9	0.6	0.8	14.2	310
Pineapples	89.3	0.4	0.3	9.7	200
Plums	78.4	1.0	..	20.1	390
Prunes, fresh	80.2	0.8	..	18.5	360
Raspberries, as purchased	85.8	1.0	..	12.6	255
Strawberries	90.9	1.0	0.7	6.8	175
Watermelons	92.9	0.3	0.1	6.5	130
Whortleberries, as purchased	82.4	0.7	3.0	13.5	390
FRUIT, DRIED:					
Apples, dried, as purchased	36.2	1.4	3.0	57.6	1,225
Currants, dried, Zante, as purchased	27.9	1.2	3.0	65.7	1,370
Dates, dried	20.8	2.2	5.1	70.4	1,565
Prunes, dried	26.4	2.4	0.8	68.9	1,360
Raisins, as purchased	14.0	2.5	4.7	74.7	1,635
NUTS					
Chestnuts:					
Fresh	38.5	6.9	8.0	44.0	1,300
Dried	5.8	10.6	10.0	70.9	1,940
Cocoanut, prepared, as purchased	3.5	6.3	57.4	31.5	3,125
Peanuts	9.2	25.8	38.6	24.4	2,560
MISCELLANEOUS					
Chocolate	10.3	12.5	47.1	26.8	2,720
Cocoa	4.6	21.6	28.9	37.7	2,320

I introduce also, in addition to Atwater and Woods' figures, a few illustrations of the total daily amount of certain food-articles necessary to maintain a nutritive equilibrium if these substances constitute the sole diet. These figures refer almost exclusively to food-articles that are much used in the sick-room, and are, therefore, often used alone or nearly so. The figures may serve to modify one's ideas of what one is

accomplishing with some of these foods. Mention of the surprisingly low food-worth of some of them is not, however, intended to cause a stampede toward an increase of sick-diets in general. As has repeatedly been said, one of the most important things in many illnesses is to reduce the diet very low, purposely, in order to save the patient, as far as possible, from digestive, metabolic, and excretory strain. The purpose of giving these figures is merely to show exactly what is being done in such circumstances, so that one may act knowingly and make no blunders through misconception.

In illustrating the value of these articles of the sick-diet I shall refer to a "sick man," meaning thereby a man of average frame, absolutely at rest, usually already somewhat emaciated, and limited, through the nature of his illness, to a very restricted diet. Owing to his absolute rest and emaciation he needs decidedly less food than the normal man of the same body-frame who is not emaciated and is leading a normal life, although not at work. Such a man as the last mentioned I shall indicate by the term "normal man."

I shall consider that the normal man requires about 2500 calories to maintain a nutritive equilibrium, while with the sick man 1500 calories is usually quite sufficient to strive for; the latter amount, in the absence of destructive toxic influences, will ordinarily nearly or quite maintain an equilibrium in such a sick man. Toxemias of acute or chronic diseases, of course, increase the difficulties and would make a larger fuel-value of the food necessary, in order to maintain an equilibrium; indeed, they often make it impossible to avoid tissue-loss by the most careful and free dieting. The protein of the normal man I shall set at 3 ounces (a little less than 100 grams); that of the sick man, at 2 ounces, which is, I think, sufficiently low.

The figures given are approximate, because the food-articles vary in value. The variations in any case, however, are not such as to have an important influence upon the conclusions to be derived from the figures.

The fuel-value of milk is such that the normal man would require about 3½ quarts to furnish sufficient total energy, or about 5½ pints to furnish the required protein. The sick man would require about 2 quarts for total energy, or about 3½ pints for its protein. Of much koumiss, a normal man would require about 7 quarts for total energy, or over 4 quarts for protein; the sick would require about 4 quarts for total energy, or 2½ quarts for protein. Of an average beef-broth, which varies in composition, the requirement for the normal man would be about 15 quarts for total energy, or about 4 quarts for protein; while of the same food-article the sick man would need 10 quarts for total energy, or 3 quarts for protein. Of expressed beef-juice, the sick man would require 8½ quarts for total energy, or 2 quarts for protein.

By way of conclusion I would say that, as in other divisions of treatment, it appears to me that in dietetics continued study of the

subject leads one to simplify his methods rather than to add complexity to them, and it especially leads me to make whatever regulations or suggestions are made fit the individual and his known deviations from normal physiologic conditions instead of attempting to make them suit the particular disease that the patient may happen to have. The latter can occasionally be done to a considerable extent, as in diabetes, but the difficulty that many persons find in using dietetics satisfactorily is largely dependent upon an attempt to do this in nearly all instances, and it is necessarily difficult, because it is impossible. As a rule, our knowledge of the precise nature of the nutritional disturbances in any disease is too general to make it possible to construct details of diet that are peculiarly suited to that disease as such. Our regulations will be found to be very much the same in many particulars in a large variety of conditions, and some of the most important regulations that we employ are used in nearly every case. This is inevitable because our conceptions of diseases of various kinds are really pictures made up of a certain number of recognizable disorders of function, one combination of these being present in one instance, others in other instances, but the combinations are, from the standpoint of treatment, often essentially the same in diseases of very diverse general pathologic character. For example, dietetic regulations in cirrhosis of the liver, in arteriosclerosis, and in chronic nephritis are often almost precisely the same, and yet proper dietetic orders are in these conditions much more important than any other part of the treatment, except the general hygienic regulations.

The most important things that we actually do in employing dietetics are really comparatively few in number in most cases: first of all, in most cases one of the most important things we do is to study carefully the dietetic habits of the individual and correct anything that would be essentially wrong for any one. The great variety of errors in diet that we find, and the commonness with which they are present, makes this one of the most important features of dietetics, and it must always be remembered that it is not a question of discovering a person's indulgences only, but frequently of discovering rather bizarre fancies, or peculiar family customs, and a variety of other things which unconsciously to the patient are doing him harm. Then we must determine whether the patient is undernourished, overnourished, or normally nourished, and if he is either of the former, we must correct this, if possible, by choosing amounts and kinds of foods according to their known values. Then, in a large proportion of cases, whatever the disturbance, particularly when it is digestive, we shall find it desirable to limit temporarily both the amounts and the kinds of foods, that is, to put the patient upon a somewhat insufficient diet for a very short time, and upon an extremely simple variety of foods, in order that opportunity for rest may be given as an important part of overcoming the effects of previous errors. This, however, is by no means always to be done, as in many cases the patient

needs from the first to get more generous feeding, and in any case underfeeding should continue for only a short time, and the patient's general nutrition must be constantly watched, as there is always danger of damaging it through dietetic regulations unless this is guarded against. In disturbances of digestion, whether the main condition producing them is disease of the digestive organs or of some other kind, we are influenced relatively little by the name of the disease, except in sc far as we know that the disease involves certain dangers, and, therefore, demands a severity of restriction that we otherwise might not use. We are influenced, on the contrary, first by the evidences of irritation, and in accordance with the severity of any signs of irritation, such as nausea, vomiting, pain, gastric hypersecretion, diarrhea, etc., we permit only foods that are more or less simple and bland in their physical and chemical characters. Again, we always have in view the necessity of stimulating peristalsis and the expulsion of fecal matter by choosing foods that leave a residue or that yield substances that excite peristalsis, or, on the other hand, if this function is already excessive, we exclude precisely such foods and use those that have the contrary effect. Finally, and in a large proportion of digestive cases, most important of all, we determine, by a study of the feces, which type of foods is giving disturbance, and just as is done in infants and young children, we restrict the protein, carbohydrates, or fats in accordance with this; or, better, when possible, we choose reasonable quantities of these from those forms that are easily digested and do not readily decompose in the digestive tract. The principles that have been established by the careful studies of pediatrists are nearly as applicable to adult patients as they are to the very young, and they need to be followed much more than they are. Indeed, pediatrists are much more rational in their dietetics than are the mass of those who deal with adults; very naturally, however, because it is so much easier for them to determine, in the much less complex pathologic circumstances of very early life, what is chiefly at fault.

In dealing with diseases which lie beyond the digestive tract, we have, in most instances, except in diabetes and obesity, only general conceptions to work upon, such as the existence of intoxication, for example, which demands some flushing with water, limitation of the foods to such as are relatively easily metabolized and excreted, and restriction of the amounts of these as closely as can be done without damaging general nutrition—all this so that the powers of metabolism and excretion may be spared for the control of the toxemia; or we know, for example, in hepatic cirrhosis and such conditions that something is causing chronic irritation, and we make regulations that are, in the main, the same as those above mentioned, in order to meet these conditions. Much the same thing is true in chronic nephritis. In other conditions there are certain details that are especially suitable in some of these conditions, rather than in others, but the most valuable of all the regulations that we possess are covered by a scheme such as

that I have sketched, and one strikes much nearer his aim if he fixes such a scheme as his basis of action, and slowly adds special details, as study and experience demonstrate to him their importance, than if he starts with the belief that he must arrange first the details to fit each condition.

THE DIETETICS OF INFANCY

By Maynard Ladd, M.D.

It is generally considered, by competent authorities, that the great mortality during the first year of life depends primarily upon mismanagement of the feeding problem. The responsibility for the ignorance of parents regarding the principles governing the nutritive demands of the infant rests largely with the physicians, to whom ultimately the question is referred. The crude and, for the most part, irrational methods of feeding widely advertised by the manufacturers of proprietary artificial foods have deceived parents, and have warped the judgment of physicians relative to the fundamental laws on which the dietetics of infancy are based.

The diseases of nutrition, such as rachitis, infantile scorbutus, infantile atrophy, and the various disorders of the stomach and intestines are caused largely by improper feeding or contaminated milk or by both conditions. They contribute directly to the infant mortality, and, in addition, in a large percentage of cases, are the causes predisposing to specific infections.

The feeding problem thus becomes a matter of extreme importance, not only in the rearing of healthy infants, but in the prevention of disease. The foundation for health is laid in these first years of life. Many of the defects of later childhood, such as backward physical development, deformities of the bones, carious teeth, chronic indigestion of different types, and susceptibility to infection, with its manifold group of symptoms, can be traced in part to violations of the rational principles of feeding in the first two years of life. The results which may be obtained by the practice of the principles of scientific feeding will fully repay any physician for the time and effort required to master the details. As a matter of public health, a practical working knowledge of the modern methods of infant feeding becomes an imperative duty.

BREAST-FEEDING

The superiority of breast-feeding over all methods of substitute feeding, when the mother's milk is of proper quality for the individual infant, admits of no discussion. It is the most convenient and economic method. In the mammary gland nature has provided an organ which secretes a food containing all the elements necessary for the proper development of the body during the first year of life. It is, however, a product that varies greatly under certain conditions, but in normal lactation it provides the ideal food for the first twelve months of life,

and is the standard which is imitated as closely as possible in substitute feeding. Nature's adaptation of the quality and quantity of breast milk to the varying needs of the individual infant is one of the most striking examples of physiologic activity.

The mechanism of the mammary secretion is, however, so delicate as to be seriously disturbed upon very slight provocation, with results which may render the breast milk in any given case an absolutely unsuitable form of diet. In a general way it may be stated that the higher the mother is in the social scale, the more unstable is the product of her mammary glands, but this variability of secretion is dependent more upon the temperament and habits of the woman than upon her environment. The unstable nervous temperament, so common in the higher social life, is unquestionably influenced by the artificiality of modern society, which exaggerates the temperament, but does not directly cause it. This psychopathic tendency is seen in mothers in all stages of society, and, when present, is a constant menace to normal lactation.

It is not, however, in the nervous type of women alone that trouble arises. The normal healthy mother of equable temperament and sound common sense in the management of her daily life will, in many cases, through sheer ignorance, impair the digestion and nutrition of the infant by the changes wrought in the quality and quantity of her milk by disregarding the principles of the management of breast-feeding.

It is evident, therefore, that failures in breast-feeding are common in all stages of society, and that to insure successful lactation the physician should appreciate the importance of supervising, throughout the first year, the feeding of babies who are on the breast. They should not fall into the habit, unfortunately very frequent, of assuming that a breast-fed baby and mother will, as a result of natural law, mutually adapt themselves to each other's needs. A slight disturbance of lactation which might easily be adjusted, if allowed to continue, often becomes so serious as to require weaning. By such neglect many infants are unnecessarily deprived of their natural sustenance.

Management of Normal Breast-feeding.—*The Care of the Breasts.*—If free from fissures and excoriations, the breasts require nothing more than scrupulous cleanliness. They should be bathed before and after nursing with cold water that has been boiled, or with a 2 per cent. solution of boric acid. If there is sensitiveness without any lesion, the nipple should be wiped with alcohol after the nursing. A piece of folded linen or other soft absorbent material should be so arranged as as to protect the nipples from contact with the clothing, and to absorb any overflow from the breasts.

Depressed nipples, especially in a primipara, may cause considerably difficulty in nursing, which reacts unfavorably upon the mother's nervous system and prevents the infant from getting its full quota of food. In these cases the breast-pump may be applied before the nursing to elongate the nipple, while in extreme cases the nipple-shield

must be used until the nipple has been normally developed. If the depression persists in spite of these measures, the breast-milk seldom retains its quality, and early weaning becomes necessary.

Caking of the breasts occurs commonly in the beginning of lactation when the supply is excessive. It can be prevented by judicious use of the breast-pump after each nursing. When the nodules have actually formed, gentle massage of the breasts with lanolin and the application of a breast bandage will relieve the condition.

In very severe cases or with threatened abscess formation ice must be applied constantly and nursing from the affected breast stopped. If suppuration occurs, the treatment becomes surgical.

Fissures and *excoriation* of the nipples require special treatment. If not severe, plain boric-acid ointment, or the compound tincture of benzoin, should be applied after each nursing after the nipple has been bathed with sterile water. It is important to detect the first indication of trouble, and to remove the source of irritation. This can be accomplished either by taking the child from the breast entirely and removing the milk by means of a breast-pump, by massage, or by using a nipple-shield. If the shield is partly filled with breast milk before applying, the infant will nurse from it more readily. In the mean time the nipples must be gently bathed with the boric-acid solution, dried, and the compound tincture of benzoin applied thoroughly with a camel's-hair brush. In still more severe cases it will be necessary to touch the fissures or excoriations with a finely sharpened point of stick of silver nitrate. The treatment should be continued until all soreness and pain have disappeared, for prolonged suffering on the part of the mother is likely in time to change the quality of the breast milk and cause indigestion in the infant. If remedies other than those mentioned are applied to the nipple, it should be with full regard to the effect they may exert if partially absorbed by the child in the act of nursing; poisonous substances, therefore, should be avoided.

The *formation of regular habits of nursing* should be insisted upon as an essential factor in the establishment and maintenance of normal lactation. No mistake is more common or more productive of error than to allow an infant to nurse at irregular intervals. It is a habit, among the lower classes particularly, to nurse whenever the infant cries. The result is that many infants are put to the breast at very frequent and irregular hours. Such a practice tends to produce a concentrated milk, which is a fruitful cause of gastric and intestinal indigestion. The food becomes too strong, and the stomach and the intestines are continually called upon to exercise their functions of digestion without the intervals of rest that are physiologically necessary. The drain upon the mother increases in proportion to the frequency of the feeding, and if allowed to continue too long, brings about a condition which cannot be remedied even by the institution of regular habits of nursing.

Number of Daily Feedings.—In breast-feeding, as in substitute feeding, we must take into consideration the individuality and idiosyn-

crasies of the digestion of the infant. Rules for feeding cannot be prescribed without admitting the desirability of variations in particular cases; but, in general, the following may be taken as a guide for the number of, and the intervals between, nursings at the different periods of the first year:

Age of Infant	Intervals in Hours	Number of Feedings in Twenty-four Hours	Number of Night Feedings
1 week	2	10	1
2 weeks	2½	9	1
4 weeks	2½	8	1
6 weeks	3	8	1
3 months	3	7	1
5 months	3	6	0
10 months	3	5	0

In this schedule the day feedings are supposed to begin at 6 A. M. and to end at 10 P. M. The night feeding is usually conveniently placed at 2 A. M. This is continued until the child is five months old, when it should sleep without waking from 10 P. M. until 6 A. M. At the age of ten months the 10 P. M. feeding is omitted, sleep being unbroken from 6 P. M. until 6 A. M. If the baby is awakened and requires something, it is better to insist upon its taking a few ounces of boiled water from a bottle or a spoon, rather than to insert an extra nursing. If the practice of giving water from a spoon is begun in the early weeks of life and carried out daily, very little difficulty will be met with; but, on the other hand, if started late, the infant may become accustomed to it only after repeated and trying efforts.

Regulating the Habits of the Mother.—The difficulty of regulating the habits of the mother constitutes one of the greatest obstacles to successful lactation, irrespective of the class of society to which she belongs. Among the poor, one is confronted by poverty, unhygienic surroundings, and household cares beyond the limits of a woman's endurance. Among the well-to-do, better conditions prevail; but in the fashionable circles the combination of an excessively nervous temperament and unhealthful habits of living often renders futile a mother's sincere desire and efforts to nurse her baby. The question of exercise, diet, and social obligations must be regulated with reference to her previous habits, the essential points being to maintain, as far as is practicable, the habits to which she has become accustomed, but to correct those that are distinctly injurious. The amount of exercise, for instance, must be prescribed in accordance with the habits of the woman when well. Those who have been accustomed to vigorous exercise require more than those who have lived sedentary lives. The general principles to be followed are practically the same as during the period of pregnancy. Avoidance of fatigue from overexertion is imperative. Exercise within the limits of fatigue, so long as it does not interfere with regularity in the hours of feeding, is to be encouraged. The food should be simple, abundant, easily digested, and varied in character. Excessive consumption of either meats or

vegetables is to be avoided. Large quantities of milk and gruel and cocoa tend to increase the flow of milk. Alcoholic drinks should be prohibited, or at least very strictly limited. Preparations of malt may be given with care, and in some cases are of decided benefit in increasing the percentage of fats. Indigestion should be promptly treated. Constipation, which is common after the weeks of inertia preceding labor, should be carefully guarded against, and, as far as possible, counteracted by appropriate changes in the diet or by mechanical measures, such as the use of injections or suppositories. If laxatives are required, some palatable form of cascara sagrada is to be employed. Pills or preparations containing belladonna and the salines are to be avoided, as they have a tendency to check the secretion of milk. Opium, morphin, the iodids, mercury, arsenic, the salicylates, and alcohol are all likely to be eliminated in part through the milk.

Nothing is more disastrous to the quality of the milk than worry and emotional excitement. Anything that tends to disturb the equilibrium of the nervous system is a source of danger, and should be scrupulously guarded against. The extent to which a mother may safely enter into her social obligations must always depend upon the effect they produce upon her physical and mental condition. It is, therefore, a question demanding much tact and judgment upon the part of the physician, and one concerning which no general rules can be laid down.

Evidence of Normal Lactation.—In judging of the results of breast-feeding in any given case we must fully appreciate the fact that it is the equilibrium between digestion and nutrition that constitutes success. A child may digest its milk perfectly and yet drop steadily behind in its weight development. On the other hand, it may make satisfactory gains in weight from week to week in spite of persistent symptoms of gastric and intestinal indigestion. In both cases the indications for regulating the feeding are present.

It is desirable in breast-feeding and in substitute feeding to keep careful records of the state of the digestion and of the weekly gains in weight. A child in whom the equilibrium between digestion and assimilation is well established shows the unmistakable signs of good health. It is free from vomiting and colic. Its sleep is restful and regular. It is always eager to nurse, and is satisfied at the end of the prescribed period of fifteen or twenty minutes. It cries only when disturbed by urination, defecation, or hunger shortly before nursing. The movements are regular, one or two a day, smooth, of a light yellow color, mush-like consistency, and of a slightly fecal, but not foul or sour odor. Its weekly gain in weight is regular, but varies greatly according to individual peculiarity.

Weight Development.—The importance of weight development as an indication of the nutrition of the infant is very great, and furnishes us, both in breast and substitute feeding, with the most valuable evidence as to the success of the feeding in any particular case, or as to the necessity of instituting some change.

The weight of the average healthy infant during the first twelve months of life has been carefully worked out by Holt. These averages are based on the result of over 10,000 observations on infants who were healthy and digesting normally. The weight curve is shown in the following chart:

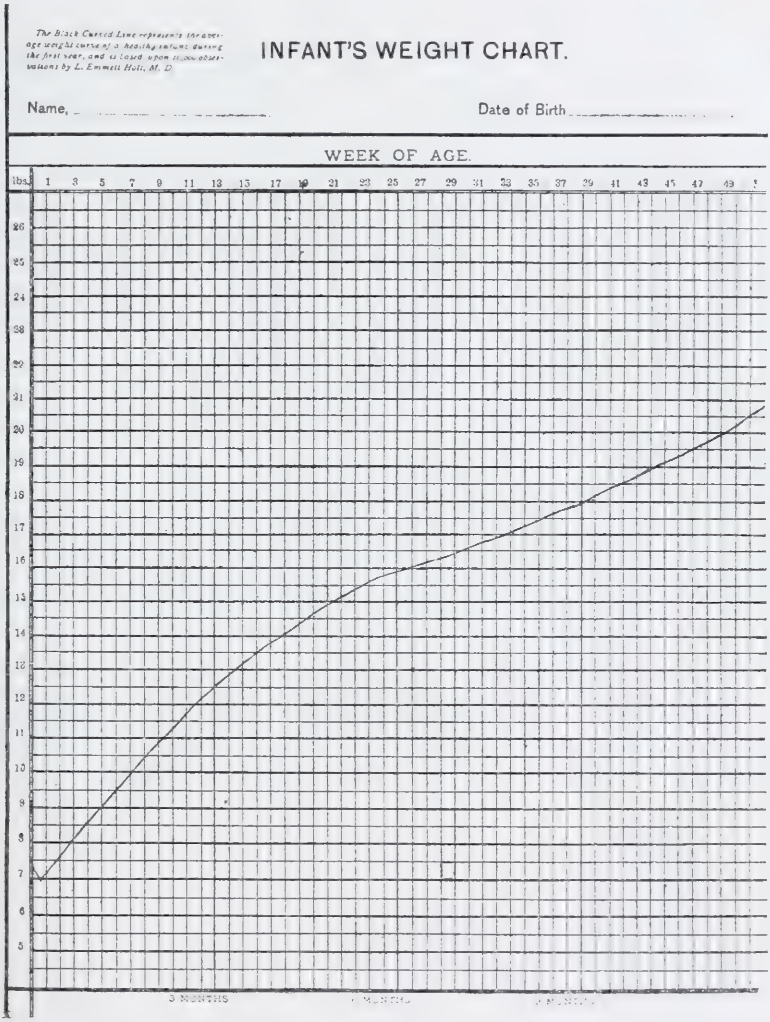

Fig. 1.—Infant's weight chart.

This curve represents not only the weight development of the average healthy infant, but it gives us also the standard of development by which to compare the progress of any given infant. In every well-regulated nursery such a record of the weight should be kept throughout the first year.

It is evident that the rate of growth varies during the different months. This variation may be expressed as follows:

	Total Gain in Pounds	Weekly Gain in Ounces
First three months	5	6
Second " "	$3\frac{1}{2}$	4
Third " "	2	$2\frac{1}{2}$
Fourth " "	3	3

Our standard of what constitutes satisfactory progress, therefore, must depend upon the age of the child and the general course of the weight curve. We cannot take the average gain per week of an infant two months old as a standard by which to judge another infant of eight months, for in the infant of two months there is an inherent tendency to gain weight faster than in the infant of eight months.

Weight Index.—The weight curve as plotted above may very properly be taken as a constant by which we may estimate the percentage development of any infant in comparison with the average infant. To express this relationship between a given case and the average infant we have used the term weight index, that is:

$$\text{Weight index} = \frac{\text{The weight of an infant}}{\text{Weight of the average infant of the same age.}}$$

If the weight index is multiplied by 100, the result expresses in per cent. the weight development of the infant.

The weight index enables us to express in definite percentages the relative progress made by infants of different degrees of development. By means of it we may also compare a gain or loss in percentage development of one quarter of the year with that of another quarter, in the same infant, or in two infants of different ages whose nutritive development we are comparing.

Composition of Human Breast Milk.—Breast milk varies much in its composition, as shown in analyses of specimens taken from fourteen mothers who were healthy and whose infants were digesting normally and gaining in weight. The average composition was:

Fat	3.62 per cent.
Sugar	6.40 "
Proteids	2.70 "
Salts	0.18 "
Total solids	12.90 "
Water	87.10 "

The extremes in the variations were:

	High	Low
Fat	5.16	2.02
Sugar	7.30	5.68
Proteids	4.17	1.08
Salts	0.21	0.12
Total solids	15.30	10.32

Other series of analyses by different chemists show equal degrees of variations. As the standard of breast milk must be determined by the effect of the milk on the digestion and nutrition of the infant, a

chemical examination without the clinical history may lead to erroneous conclusions as to the quality of the food in any given case. The especial point to be emphasized by such figures is that the variations in the milks indicate corresponding variations in the needs of different infants for percentages of fat, sugar, proteids, mineral matter, salts, and water. Each infant has his own personal equation as regards the quantity and quality of the food which it requires. The breast milk of one patient in the above series which was agreeing perfectly with the infant might, as has been repeatedly shown in cases in which a wet-nurse has been substituted for a mother, prove absolutely unsuited for the child of another woman whose nutritive equilibrium was established on a much lower plane. In substitute feeding, therefore, one does not strive wholly to duplicate the average composition of human milk, but, following the lead of natural law, one seeks to combine the percentage of fats, sugar, and proteins in such a way as to meet the individual requirements.

It is impossible, therefore, to divide sharply breast milks into those which are normal and those which are abnormal. It is better to adopt some standard for the composition of human milk which, for practical purposes, may be placed as: Fat, 4 per cent.; sugar, 7 per cent.; proteins, 1.5 per cent.; and salts, 0.15 per cent.; and by this standard to form a general impression as to whether milk is "poor," "overrich," or "bad." Examples of this may be illustrated in the following table from Rotch's "Pediatrics."

	Normal Milk	Poor Milk	Overrich Milk	Bad Milk
Fat	4.00	1.10	5.10	0.80
Sugar	7.00	4.00	7.50	5.00
Proteid	1.50	2.50	3.50	4.50
Mineral matter	0.15	0.09	0.20	0.09
Total solids	12.65	7.69	16.30	10.39
Water	87.35	92.31	83.70	89.61
	100.00	100.00	100.00	100.00

These divisions are arbitrary and relative, and are of value only as a general guide to the character of the food. A milk that is "bad" cannot be improved. A "poor milk," with low fats and sugars and moderately high proteids, may or may not be altered so as to approach more closely to the standard, but it is worth the experiment. An "overrich" milk can almost always be adapted to the infant.

Colostrum.—During the first three or four days the quality of breast milk is quite different from that which is secreted after the function of the mammary glands has become established. This early milk is called colostrum, from the presence of the colostrum corpuscles. These corpuscles disappear from the milk within a week or ten

days. They are to be looked upon as the result of immature mammary secretion, and if they persist beyond the usual time and are associated with signs of indigestion in the infant, may be considered as an indication for temporary or permanent cessation of the breast-feeding. Colostrum milk is very high in proteins and low in fats and sugar, which is quite the reverse of the normal breast milk, which reaches its average composition by the end of the second week. The apparent immunity of the nursing infant to the high proteins of colostrum milk in the first few days is probably due partly to its scanty secretion, and partly to the deficiency of hydrochloric acid, which allows the milk to pass quickly into the duodenum without the formation of the hard curds of paracasein. The poisonous character of the colostrum when the period is prolonged is dependent upon the increased secretion of milk and the consequent larger ingestion of the excessive amount of proteins, which may analyze as high as 5 or 6 per cent., and prove too great a tax on the undeveloped functions of the stomach.

Quantity of Breast Milk.—After the milk has attained its average strength, very little change occurs in its composition normally. The physiologic adaptation of the mammary secretion to the increasing requirements of the infant is almost wholly in the quantity of the milk secreted. Both in the twenty-four-hour amount ingested and in the quantity at each nursing one sees great differences in different infants according to their individual needs. Larger infants take more milk than those who are small, both in actual amounts and in proportion to their body-weight.

In estimating the quantity of milk that a mother may secrete we may judge, by the appearances of the breasts, by the weight of the infant before and after nursing, and by the length of time it takes the baby to satisfy its hunger. In determining the composition of the breast milk a chemical examination is necessary. For this purpose the contents of one breast should be wholly withdrawn by means of a breast-pump, since there is a marked difference in the composition of the foremilk, the middle milk, and the strippings, as shown in the analyses quoted by Foster:

	Foremilk Per cent.	Middle Milk Per cent.	Strippings Per cent.
Fat	1.71	2.77	5.51
Protein	1.13	0.94	0.71

One can seldom withdraw with a breast-pump as much milk as a baby will obtain by nursing. Samples of breast milk, therefore, consist mostly of the fore and middle milks, the richer strippings being left behind. Chemical analyses of the milk may consequently be misleading, especially in reference to the fat-content.

Influence of Nervous Disturbances.—Any condition which reacts upon the mother in such a way as to upset the equilibrium of her nervous system is likely to cause decided changes in the quality of her breast milk. The most frequent alteration is in the percentage of the proteins, which may be increased to 3 or 4 per cent. or even higher,

while the fats are reduced often to less than 1 per cent. Outbursts of temper, emotional excitement, worry, mental shocks from many causes, fatigue, and exhaustion cannot be too carefully guarded against. The changes in the milk produced by such disturbances may be immediate or gradual, according to the exciting cause. The effect upon the infant, consequently, may be noticed at once or may be of slow development. It may be so serious as to necessitate temporary or immediate withdrawal from the breast until the milk has been readjusted to its normal condition. Nervous and mental states also play an important part in the quantity of the milk. Fear on the part of the mother that she cannot possibly nurse her infant is often the only cause of scanty secretion.

Influence of Menstruation.—Contrary to the impressions held by many women, nursing from the breast of itself does not prevent either the return of the menses or conception. The changes produced in the milk by the reappearance of the menses are not definite. In many cases no alteration is noticed; in others the fats may be reduced and the proteins increased, giving rise to temporary indigestion in the infant. Much depends upon the stability of the nervous system. In neurotic or neurasthenic women who in health suffer greatly at the time of their flow one may expect considerable variation in the composition of the milk. The question of the continuance of nursing under these conditions must depend wholly upon the degree of disturbance in digestion and nutrition in the infant caused by the altered breast milk. Menstruation *per se* is not a contraindication to nursing.

Influence of Pregnancy.—If a woman becomes pregnant while nursing, it is not unusual to notice, coincident with the progress of the case, a gradual diminution in the quantity and quality of the milk, especially in the fats. This is due to the drain upon the mother in her effort to nourish two infants instead of one. It is rarely wise to subject a mother to such a strain for many weeks, but it is by no means always necessary to wean the infant immediately upon making the diagnosis of pregnancy. Nursing is said by some authorities to increase the tendency to miscarriage. However that may be, it is a general rule that nursing is incompatible with pregnancy; but the time for weaning must be judged by the indications in the individual case. If the child is free from indigestion and is gaining in weight, and the mother shows no signs of exhaustion, the infant may safely be nursed for eight or ten weeks after the determination of pregnancy; but it is rarely advisable to prolong the breast-feeding beyond that time.

Influence of Acute Infections.—It is difficult to lay down rules regarding the management of breast-feeding when the mother is taken with an acute illness. In no case should her interest be sacrificed for the sake of the child, for modern methods of substitute feeding, intelligently applied, are so well developed that a physician should not hesitate to wean an infant if the mother's health makes this desirable. In the acute, non-septic fevers bacteria do not appear in the breast milk, and if the strength of the mother permits, nursing may be continued.

If the mother is tuberculous, or exhibits a strong tendency toward tuberculosis, nursing is contraindicated. In suppurative inflammation of the mammary glands, and in puerperal and other septic conditions, bacteria may be eliminated in the milk—from which it is well to protect the infant. In diphtheria, whooping-cough, and severe forms of contagious diseases it is safer not to permit nursing, although it has been shown that a certain amount of immunity is often conveyed to the infant through the milk in cases of measles, scarlet fever, diphtheria, mumps, and typhoid fever, probably through the elimination of immune bodies. The acute diseases, if severe, often cause the milk entirely to disappear, even when the nursing is continued. It is better, therefore, to wean the baby at once, or at least to reduce the number of breast feedings.

Effects of Variation of the Breast Milk Upon the Infant.—Whatever the cause, the characteristic changes in the milk produced by disturbance in the mammary secretion usually consist of a diminution in the percentage of fats and an increase in the percentage of proteins. The milk may or may not be diminished in quantity. The effect upon the infant is usually the production of gastric or intestinal indigestion, and if long continued, of loss of weight or retarded physical development. Sometimes the vomiting and diarrhea are accompanied by symptoms, such as pain, fever, convulsions, and shock, so severe as to suggest acute poisoning. One sees, therefore, all grades of disturbance from the mildest forms, characterized only by slight discomfort and regurgitation, to the alarming condition of intestinal intoxication. Causes acting in such a way as to weaken the milk as a whole and lessen the quantity result only in restlessness and irritability during the day, sleeplessness at night, and malnutrition. In such cases careful observations of the weight development furnish the indication as to the wisdom of continuing the breast-feeding. Bad breast milk may be as productive of danger to the child as an improper modification of an impure milk supply.

Treatment of Disturbed Lactation.—In normal breast cases very little supervision of the feeding is necessary, aside from regulating the number, intervals, and length of feedings. In the management of the pathologic cases, however, the greatest difficulty is often experienced. The treatment is of two kinds: that directed toward the mother, the source of the trouble, and that which applies to the infant.

It is essential to inquire in great detail into the habits of nursing, the mother's health, diet, and manner of living, and to correct, as far as possible, the errors and indiscretions which are detected. The main object is to restore the normal physiologic function of the mammary glands. An examination of the breast milk will often show whether or not the quality of the milk is such as to justify the time and effort necessary to rectify it. Assuming that it is capable of improvement, the following rules laid down by Rotch will be found to be excellent guides in meeting the indications suggested by the examination of the milk:

General Principles for Guidance in Managing a Disturbed Lactation.

To increase the total quantity:	Increase proportionately the liquids in the mother's diet, and encourage her to believe that she will be enabled to nurse her infant.
To decrease the total quantity (rarely necessary):	Decrease proportionately the liquids in the mother's diet.
To increase the total solids:	Shorten the nursing intervals; decrease the exercise; decrease the proportion of liquids in the mother's diet.
To decrease the total solids:	Prolong the nursing intervals; increase the exercise; increase the proportion of liquids in the mother's diet.
To increase the fat:	Increase the proportion of meat in the diet and of fats which are in a readily digestible and assimilable form.
To decrease the fat:	Decrease the proportion of meat in the diet.
To increase the protein (very rarely indicated):	Decrease the exercise.
To decrease the proteins:	Increase the exercise up to the limit of fatigue for the individual.

One should never lose sight of the fact that the most important underlying principle of all is the removal of the cause affecting the mother. If habits of life or family worries are at the bottom of the trouble, no rules which can be given will avail. A mother is often in a very weakened condition following labor. Her digestion and health must be attended to according to the general principles of hygiene and therapeutics. Tears of the cervix and the perineum should be repaired as soon as practicable. Fresh air, exercise; tonics, aids to digestion, laxatives, and proper food should be prescribed. Above all, she should be encouraged in her hopes that she will in time be able to nurse her baby.

The treatment of the infant in the great majority of cases is wholly through the mother. It is necessary, however, in the more difficult cases, to take the child temporarily from the breast and to give it a properly modified milk. The mother's milk is then regularly withdrawn by means of a breast-pump, while her own treatment is being carried out. This will relieve her of the anxiety she naturally feels from noticing the effect of her milk upon her child.

When the symptoms of indigestion are mild, the baby should be kept upon the breast milk, and while the mother is being treated, the infant's symptoms should be met by appropriate remedies. If the vomiting, for instance, is due to a milk that is abundant, but too rich, the nursing period may be limited to the foremilk and middle milk, while the strippings are withdrawn by a breast-pump and discarded. One should bear in mind that overdistention of the stomach is one of the commonest causes of vomiting in breast-fed infants. Weighing the baby before and after each nursing will show the quantity of milk taken. Vigorous new-born babies who have an abundant milk supply to draw upon will often take from four to five ounces at a feeding. The inevitable result is dilatation of the stomach and severe vomiting. These cases at times closely simulate pyloric stenosis. The quantity

of milk can be regulated to any desired number of ounces by reducing the number of minutes of nursing, the weight of the baby before and after nursing serving as the measure of the milk the baby receives.

If the milk is scanty and too rich, the baby may be given boiled water, diluted lime-water, or a weak sodium bicarbonate solution, before each nursing. If there is intestinal indigestion, with loose movements, bismuth subnitrate in 3- to 5-grain (0.2 to 0.3 gm.) doses may be tried from three to six times a day. A new preparation, known as "milk of bismuth," makes a very satisfactory form in which to prescribe the bismuth in suspension. Constipation is best relieved by small doses of milk of magnesia. Colic that persists in spite of regulation of the bowels and dilution of the milk as prescribed may in some cases be relieved by 10- to 20-drop (0.5 to 1 c.c.) doses of essence of pepsin, or by 3- to 5-grain (0.2 to 0.3 gm.) doses of saccharated pepsin before each nursing.

Weaning.—*Indications for Weaning.*—The time when the breast-fed infant should be weaned depends upon the state of its digestion and nutrition, rather than upon its age or the season of the year. Very few mothers in the upper classes can successfully nurse their babies throughout the twelve months. Deterioration in the milk, either in its quality or quantity, may begin at any age. Usually between the sixth and the ninth month it becomes necessary to wean the child entirely or to supplement the mother's feeding with a modified cow's milk. In the most robust infants it is rarely desirable to continue breast milk into the second year. This practice is very common, especially among the poor and ignorant. If the end of the first year happens to come in the late spring, the mistake is continually made of attempting to nurse the infant through the summer. The effort is almost always at the expense of the infant's welfare. If one can control a reliable milk-supply and can depend upon intelligent modification and adaptation, it is much safer to wean than to attempt to prolong the lactation beyond the natural limits.

In the matter of weaning, as in feeding in general, the condition of the child's weight is the surest guide as to the wisdom of changing the food. If the child is free from indigestion, but gains slowly, and thus drops steadily behind in its weight development, the indications are clear for partial weaning, that is, to substitute two or three bottles for the same number of breast-feedings. If the child does not gain at all, or if it loses weight steadily for two or three weeks, mixed feeding is likely to fail and to compel the physician to adopt substitute feeding exclusively. If indigestion alone is the evidence of the disturbed lactation, conscientious efforts should be made to remedy the quality of the milk by the measures already described. If, in two weeks' time, the exciting causes having been removed, no progress is made in relieving the symptoms and improving the nutrition, it will generally be wise to wean. In any given case the reaction of the breast milk upon the infant may be so severe as to make immediate cessation of nursing imperative. Gastric and intestinal disturbance of a severe form,

combined with loss of weight and a milk which is deficient in quantity and "poor" or "bad" in quality, constitutes a condition that can be little improved, and weaning is indicated in the interests of the mother and the child.

The advent of acute diseases may or may not be an indication for weaning. The milder illnesses often have little effect upon the milk. If the mother is very ill, she should not be subjected to the strain of nursing when substitute feeding can be so satisfactorily employed. It is often well, however, to take the child away from the breast temporarily and to maintain the flow of milk by means of a breast-pump, emptying the breasts four or five times a day until it is determined what course the disease is to take in the mother, and what are her chances of being able to nurse when convalescence is established.

It is obviously impossible to lay down more than the most general indications for weaning. In any particular case it is a question of striking a balance between what is best for the mother and what is desirable for the infant. Much has been written about the heedlessness of physicians in advising mothers to wean upon slight provocation. It is true that many flagrant examples of poor judgment in regard to such cases are seen, but it is also common to see instances in which lactation is unwisely allowed to continue in spite of symptoms of indigestion and malnutrition which the physician is unable to regulate through the breast milk.

Method of Weaning.—Whenever possible, an infant should be gradually weaned, at least a week being taken to substitute the bottle for the breast-feedings. The milk should be modified according to the principles to be described under substitute feeding. The formula and quantity at each feeding should be kept a little below those which are ordinarily given to a bottle-fed baby of the same age. One bottle each day is then substituted for a breast-feeding. If the milk is not well borne, a weaker formula should be tried. When the substitution has been completed, the strength and the quantity of the milk can be increased in accordance with the general principles of percentage feeding.

If the interests of the mother or child require immediate weaning, the breast milk should be dried up by the administration of salines internally and the application of cold or iced compresses to the breasts. Fluids should be excluded from the diet. The milk formula in such cases should be the weakest, such as would be given to a new-born infant, and then by frequent, perhaps daily, changes, the strength should be increased up to its maximum as rapidly as the indications permit.

WET-NURSES

The best substitute for mother's milk theoretically is that of another woman whose child is approximately of the same age. It is not wise, for instance, to choose for an infant of one or two months a wet-nurse whose lactation has been established for nine or ten months. The chances are that her milk will soon deteriorate, and the problem

of feeding the foster child will require another solution. In this country, especially in our larger cities, the difficulty of securing desirable women for wet-nurses is very great. The majority of applicants are women who have illegitimate children and who let themselves out as a last resort for livelihood. They are often unfaithful to their trust, and require vigilant watching. This method of feeding, therefore, is applicable in a few cases only, comparatively speaking. It is also expensive, but should be tried in very severe and urgent cases, when one or two attempts at substitute feeding have failed, and the physician feels that he cannot afford further experimentation.

In selecting a wet-nurse, one should institute a most rigid physical examination of mother and child to determine the absence of all taint of tuberculosis, venereal disease, or other indications of ill health. If she is concerned in the welfare of her own child, great care must be taken to see that it is provided with a proper substitute food, otherwise she will secretly attempt to nurse both infants, which can rarely be done with success. Her life, habits, and food should be strictly regulated. A wet-nurse from the lower classes, if put into a luxurious house with an abundance of rich food, will quickly show the ill effects in disturbance of her milk in consequence of overindulgence. Her diet should be plain, her exercise enforced, and her hours of sleep regular. Such habits of life are often not easily inculcated in one whose interest is wholly pecuniary, and whose past has been without discipline or restraint.

SUBSTITUTE FEEDING

The resort to substitute feeding is usually a matter of necessity. It is the exception, not the rule, for an American mother to be able to feed her infant exclusively on breast milk for the full twelve months. Supplementary feeding generally begins between the sixth and the ninth month, and often earlier. The fact that a mother does not nurse her infant is due not so much to her unwillingness, from selfish reasons, but to the fact that she is a victim of the artificial conditions of modern life and cannot nurse because of a deficiency in the quantity or quality of her milk. The great majority of babies fed on substitutes for breast milk represent cases of failure of breast-feeding. Whereas in exceptional cases one may solve the problem by securing a competent and reliable wet-nurse, there is not in this country a sufficient number of the class from which wet-nurses are derived to meet the demand made by the enormous number of infants whose mothers, for one reason or another, cannot supply their natural food. It is, therefore, not a question as to the relative advantages of breast-feeding and substitute feeding which must be considered, but of how best to solve the problem of feeding, by artificial or substitute methods, the constantly increasing number of infants who must be reared on the bottle.

There is little question that here in America the methods of substitute feeding have been more fully developed along scientific

lines than in any other country, but the principles of the modification of cow's milk and percentage feeding have by no means been generally adopted by the profession as a whole. This is partly owing to the fact that the subject is comparatively new, and only a few of the more progressive medical schools have appreciated the importance of systematically instructing their students in these methods. The scientific modification of milk and percentage feeding are followed, for the most part, by those whose practice is especially among children. It is owing to the unfamiliarity of the general practitioner with these principles and their aversion to mastering the details of a somewhat difficult subject that infant mortality in the first year has reached such alarming proportions. The introduction of proprietary foods has not, and never will, solve the problem of substitute feeding of infants. Fresh, clean cow's milk must be the basis of successful feeding, and the knowledge of the principles by which such milk may be modified in its percentages and adapted to the varying needs of human infants becomes of vital importance to the welfare of the race.

A new-born infant, starting life in perfect health, can be successfully reared on properly modified cow's milk with almost the same degree of certainty as when fed from the breast, but requires more care and attention on the part of the physician and the nurse. On the other hand, if the feeding is not intelligently directed from the very beginning, if gastric and intestinal indigestion is allowed to develop and to interfere with the physiologic growth of the body, one often experiences considerable difficulty in restoring the normal function of digestion and nutrition, and the difficulty is almost in direct proportion to the length of time the symptoms of indigestion and malnutrition have been allowed to continue.

The Choice of the Milk-supply in Substitute Feeding.—Assuming the necessity of substitute feeding, the choice of the milk-supply becomes our first consideration. The milk of the cow, ass, mare, and goat have all been recommended, and more or less extensively used in different countries. The composition of human milk has been shown to vary, but as a fair standard for comparisons with the milks of other mammals, which are subject to equal variation, its average analysis was stated as 4 per cent. of fat, 7 per cent. of sugar, and 1.5 per cent. of proteins. If human milk is to be taken as a guide in substitute feeding, it will be instructive to observe how closely these other varieties of milk approach it in composition. This is illustrated in the following table:

	Percentage of Fat	Sugar	Proteins	Mineral Matter	Total Solids
Human milk.....	4.00	7.00	1.50	0.20	12.70
Cow's milk......	4.00	4.75	3.50	0.70	12.95
Goat's milk......	4.30	4.00	4.60	0.60	13.50
Mare's milk.....	1.09	6.65	1.89	0.31	9.94
Ass's milk.......	1.60	6.10	2.20	0.50	10.04

It is evident from these figures that the difference in the milks is not so much in the amount of total solids as in the relative proportion of the fats, sugar, and proteids. Not one of them approaches at all closely to the composition of human milk, in comparison with which cow's milk and goat's milk are low in sugar and high in proteins; while mare's milk and ass's milk are very deficient in fats. If, therefore, human milk is to be imitated in its composition in substitute feeding, some form of modification will be necessary. One kind of milk is as easily modified as another, and also presents the same difficulties. As a matter of practice, cow's milk is the most convenient, practical, and satisfactory to use. The milks of the other mammals are so seldom available in this country that they need hardly enter into the consideration of the subject.

Much has been written of the idiosyncrasy of certain infants against cow's milk. It is impossible to deny that this exists, but the more attention one pays to modification of milk to meet the especial peculiarities of digestion in different babies, the more skeptical one becomes as to these idiosyncrasies, especially when the adaptation of the percentages of the fats, sugar, and proteins is intelligently directed from the beginning of life. The difficulties in feeding met with after months of improper modification are to be referred to the chronic disturbances of the digestion which have been allowed to develop, and not to the existence of a milk idiosyncrasy.

Composition of Cow's Milk.—Milk consists of an emulsion of fat in minute subdivision suspended in the milk plasma, which consists of milk-sugar, or lactose, proteins, extractives, mineral matter, and water. It, is therefore, apparent that all the great subdivisions of food-stuffs are represented, that is, fats, carbohydrates, proteins, mineral matter, and water. The proportion in which these substances occur in the milk varies in different animals and also in the same animal at different times.

The average of a large number of analyses made in this country showed the following result (Harrington):

Fat	4.00	per cent.
Sugar	4.95	" "
Proteins	3.30	" "
Mineral matter	0.75	" "
Total solids	13.00	" "
Water	87.00	" "
	100.00	" "

Droop-Richmond gives the composition of cow's milk in England, based on the analyses of 200,000 specimens, as:

Fat	3.90	per cent.
Lactose	4.75	" "
Casein	3.00	" "
Albumin	0.40	" "
Mineral matter	0.75	" "
Water	87.10	" "

The analyses of milk by French and German chemists, as well as by many English and American investigators, show varying results, which serve to emphasize the fact, which cannot be too strongly impressed, that the composition of milk of large herds of cows, as well as of individual cows, varies sometimes within wide limits of any average that one may attempt to establish. These variations depend upon the breed of the cow, the methods of feeding, the health of the animal, the season of the year, and other conditions.

The importance of the selection of the herd in substitute feeding depends not so much upon the differences in gross composition of the milks, as upon other considerations. The volatile glycerids, for example, which are present in very small proportion in human milk, are considerably greater in Jersey and Guernsey milk than in that of the commoner breeds of cows, such as the Holsteins. They increase decidedly the difficulty of digestion. Moreover, the fat-corpuscles in Jersey milk are much larger than those of Holstein milk, and are less easily emulsified. Modifications made up from Jersey milk, therefore, are less likely to maintain their emulsion. For these reasons there is a strong theoretic argument against the use of milk from Jersey cows in infant-feeding, and in practice it is found to be much less suitable than the milk of common breeds. Holsteins, Durhams, and Ayrshires should always be selected in preference to the higher grades. The mixed milk of a herd is less variable in its composition than that of a single cow, and for this reason it is to be preferred for the purposes of infant-feeding.

Reaction.—Perfectly fresh milk is amphoteric or slightly acid, but cow's milk is relatively more acid than human milk. The acidity is due to the presence of phosphates; the alkalinity, to the presence of alkaline carbonates.

Specific Gravity.—The specific gravity varies from 1.028 to 1.034. It increases very slightly for a few hours in consequence of molecular modifications of the casein. It is dependent upon the presence of solids (not fat), which are in solution and tend to raise the specific gravity, and upon the fat itself, which, by virtue of its being lighter than water, tends to lower the specific gravity. It is lowered by the addition of cream or water, and is raised by the removal of the cream.

Fats.—The fat of milk exists entirely in the form of the fat-globules suspended in the plasma. These globules vary greatly in size. It is a disputed point whether the globules are purely fat. The percentage of fat in milk, as seen above, varies according to the breed of the cow, the season of the year, the feed, and many other conditions.

Milk-plasma contains in solution, or pseudosolution, the remaining constituents of milk, that is, the milk-sugar or lactose, the proteins, caseinogen, lactalbumin, lactoglobulin, and the mineral matter. Certain extractives are also present, that is, faint traces of urea, creatin, creatinin, xanthin, lecithin, cholesterin, and citric acid. The gases of milk consist chiefly of CO_2, N, and traces of O.

Milk-sugar, or *lactose*, is found in nature in milk alone, but has

been detected pathologically in the urine of pregnant women. When heated to 170° to 180° C., it is converted into lactocaramel, but when heated in solution, it begins to undergo decomposition at 70° C., which is a point of some significance in connection with the subject of sterilizing milk in infant-feeding. Milk-sugar does not undergo alcoholic fermentation with pure yeast, but is fermentable by the action of certain schizomycetes and by the enzyme lactase, which exists in yeast, being split by hydrolytic cleavage into glucose (dextrose) and galactose. Lactose is not acted upon by invertase, diastase, rennin, pepsin, or trypsin.

Caseinogen is the term applied to the chief protein of milk when in a state of solution. It constitutes three-fourths of the total proteins, and amounts to about 2.63 per cent. It is a nucleo-albumin and occurs only in milk. Caseinogen is coagulated by the rennin ferment in the presence of enough and not too much calcium salts. In the absence of calcium, precipitation does not take place, but the rennin effects a change in the casein, so that even if it is killed by heat, the casein will coagulate when the calcium salts are supplied, showing that the lime salts are necessary only for the separation of the curd. Caseinogen is not coagulable by heat, in marked contrast to the other proteins, lactalbumin and lactoglobulin. It is, however, coagulated by small amounts of acetic acid or mineral acids, and is soluble again in an excess of the acid.

Lactalbumin, including small traces of lactoglobulin and of other nitrogenous extractives, forms about one-fourth of the total proteins of milk, or 0.87 per cent. In human milk it is of much greater importance, constituting two-thirds to one-half of the total proteins. It is characterized by its property of coagulating at 72° to 84° C., the degree depending upon the amount of salt in solution. It is not coagulable by dilute acids or rennin. It is very similar chemically to serum-albumin. When heated to the above temperature, it is not entirely coagulated, but is so changed that it is readily precipitated by magnesium sulphate. Much stress has recently been laid upon the difference in the relative proportions of the two proteids in its application to infant-feeding. According to some analyses, however, caseinogen is in excess of lactalbumin even in human milk, but nearly all are agreed as to the relatively greater proportion of lactalbumin or soluble proteids in human milk as compared with cow's milk. The greater majority of analyses of breast milk do not attempt to give anything more than the total proteins.

It is probable that there are qualitative differences in the caseins of cow's milk and human milk, but whether these differences in the composition of the casein molecules account for the differences in the character of the coagula of the two milks, or whether the differences are due to the unequal relationship of the casein and salts in the two kinds of milk, has not been determined. It has been shown that when cow's milk is so modified by the addition of whey and cream as to correspond in its proportions of caseinogen and lactal-

bumin to that of human milk, the coagulum obtained by the addition of rennin or acids is not coarse and tough, but fine and flocculent, resembling that of mother's milk.

Chemistry of Milk Proteins.—According to the studies of van Slyke and Hart, the caseinogen in milk exists as calcium casein, which is first coagulated by the rennin ferment of the gastric juice into a soft, easily digested clot known as junket, or, chemically, as calcium paracasein. In the absence of acids this may pass readily into the duodenum and undergo pancreatic digestion. On the other hand, if organic or inorganic acids are present in the stomach, this calcium paracasein becomes first free paracasein and free casein in the presence of small amounts of acid, and then acid paracasein (such as the hydrochlorid or the lactate of paracasein) in the presence of larger amounts of the acid. True peptic digestion does not begin until the acid compounds of paracasein have been formed. If hydrochloric acid is present as free acid, gastric digestion proceeds more rapidly than if it is wholly combined.

The curds in the stage of free paracasein, and, still more, those which have gone one step farther and become the hydrochlorid or lactate of paracasein, show a great tendency to shrink and form tough, tenacious masses, which are acted upon slowly by peptic digestion, especially in the early weeks of life, when the gastric function is still in process of development. The amount of the tough curds which are formed varies according to the percentage of casein in the milk ingested and the quantity of acid secreted. If a small amount of acid is present, most of the calcium casein is retained as the readily digested calcium paracasein, while the tough, indigestible, free, and acid paracaseins are formed to a slight degree only and the tax on the gastric digestion is slight. As the infant's gastric secretions develop and the flow of hydrochloric acid increases, there is a proportionate increase in the amount of free and acid paracaseins, so that less of the stomach-contents passes directly into the duodenum, to be subjected to pancreatic digestion, and more remains in the stomach for gastric digestion. This gradual increase in the work of the stomach has much to do with its proper growth and the development of its physiologic functions. The more established the secretion of hydrochloric acid becomes, the more free acid will be present, and the greater will be the power given to the stomach to meet the extra demands put upon it.

It is not difficult to see, therefore, of how great importance the question of protein digestion becomes in substitute infant-feeding. The administration of percentages of casein beyond the individual child's stage of protein digestion will obviously cause serious disturbance in gastric and intestinal digestion. The wisdom of keeping the percentages of casein low in the early weeks and giving the maximum amount of the soluble proteins in the form of whey has, therefore, a scientific explanation aside from the results clinically observed in the practical use of whey in infant-feeding.

Mineral Matter.—The total mineral matter obtained by the analyses of König was 0.7 per cent. It consists chiefly of K, P, Ca, Cl, and S, with very small traces of Si, Fe, and Mg. A part of the calcium is combined with casein, the remainder with phosphoric acid. It has not yet been found practicable to make use of the differences in the mineral matter of human and cow's milk in the adaptation of cow's milk to infant-feeding, but recent experimental work points strongly to the influence of the mineral matter on infant metabolism.

Action of Heat on Milk.—When milk is heated to 70° C., a certain amount of lactalbumin and lactoglobulin is coagulated, but the greater part of the lactalbumin is converted into a form that is precipitated by acids, by magnesium sulphate, and by other precipitants of casein which do not act upon the lactalbumin in its natural state. At 80° C. certain organized principles undergo a change, the nature of which is not known, but the evidence of which is found in certain chemical reactions. At 100° C. calcium citrate is deposited, some oxidation of the sugar takes place, and a deposition of albumin and certain salts on the fat-globules occurs, causing the latter to rise and coalesce. At a temperature exceeding 60° C. a skin is formed on the surface of the milk, consisting probably of an oxidized product of casein, together with calcium salts and some fat. When heated above 70° C., the taste and smell of milk are altered.

Fresh milk does not coagulate on boiling, but when lactic-acid fermentation has proceeded sufficiently, coagulation occurs on the application of heat, a phenomenon often noticed in summer when the conditions are especially favorable to lactic-acid fermentation. This is probably due to the acid developed displacing the casein from its combination with an alkali, the free acid manifesting its properties. Lactic-acid fermentation is checked by the action of heat.

Heat does not destroy the ptomains or toxins which have been formed by the growth of micro-organisms in milk: it only checks for a variable length of time the growth of bacteria and the production of their deleterious products; hence the pasteurization or sterilization of an already contaminated and infected milk can never make up for the lack of a clean, uncontaminated milk-supply. According to H. Bitter, all pathogenic germs are killed with certainty at a temperature of 68° C. (154.4° F.), continued for one-half hour, and the milk is thereby not altered in taste or appearance. Ordinarily, twenty minutes' exposure is sufficient. Most bacteria are killed at from 60° to 64° C. (140° to 147° F.); but Theobald Smith has demonstrated that the tubercle bacillus may survive an exposure of an hour at 65° C. (149° F.), so that these lower temperatures are not to be relied upon. The spores of bacteria, however, and some of the casein ferments are not destroyed by a single pasteurization. Sterilization of milk under pressure for two hours at 120° C. (248° F.) is sufficient to destroy spores. At such temperatures, however, the sugar is converted into caramel, many of the natural ferments are destroyed,

the casein is partially precipitated, and, in the opinion of many observers, the nutritive value of the milk is seriously interfered with. A temperature of 68° C. (155° F.) is that which may most profitably be relied upon for the pasteurization of milk. It is sufficiently high to kill most of the organisms that are found in milk, and at the same time does not produce any chemical changes that may be detected in the milk.

It is not known with certainty, despite the many opinions expressed on the point, as to how far the heating of the milk at low temperatures affects its digestive qualities. A milk heated at high temperatures is curdled less readily by rennin than is unheated fresh milk, but there is reason to believe that this is due to the deposition of the calcium salts rather than to any change in the casein. On the other hand, it has been claimed that sterilized milk is easier of digestion in the stomach and does not produce so firm a clot.

Effect of Cold on Milk.—Cold is a most important factor in preventing the growth of bacteria in milk. If the temperature is sufficiently low,—about 15.5° C. (31° F.),—the milk will freeze. The frozen portion does not show the same composition as the milk itself, but contains a larger proportion of water.

Separated Milk.—Separated milk is the term applied to a milk from which the fat has been wholly or partly removed, either by the centrifuge or by gravity. Obviously, therefore, it has no constant composition. Milk from which the fat has been removed by the ordinary process of skimming contains from 0.4 to 1.2 per cent. of fat. The proportions of the other ingredients depend upon the proportion of the fat removed; they are increased by the removal of the fat. If the centrifugal separator is worked to its maximum capacity, practically all the fat is separated out as cream, leaving the milk plasma, to which the term *fat-free milk* is now given. Many analyses of this milk at the Walker-Gordon laboratories have shown the fat to be approximately only 0.05 per cent. About the same percentage of fat (0.05) is to be found in the lowest eight ounces of a quart jar of milk that has been setting eight or twelve hours, so that a practically fat-free milk can be obtained by gravity and by centrifugal methods.

The slimy residue obtained from the centrifuge consists of inorganic impurities, such as dirt, vegetable matter from the fodder, and substances from the cow, such as hair, pavement-cells from the udder, empty gland-cells, micro-organisms, and sometimes pus and blood. While centrifugal cream is much cleaner than the milk from which it is derived, the process of separation does not diminish the number of micro-organisms. It has been shown that both gravity and centrifugal cream contain a much larger number of bacteria to the cubic centimeter than the whole milk from which they are obtained.

Cream is the term applied to the separated part of the milk which is especially rich in fat. It is of the same qualitative composition as milk, but with different proportions of the ingredients.

The richer the cream is in fat, the lower is its percentage of proteins and sugar. (See p. 173.)

The Production of Sterile Milk.—The production of milk free from dirt and bacteria is the first consideration in any ideal method of infant-feeding. The standard for such purity is to be found in human breast milk. This practically is a sterile fluid, and its freshness and freedom from bacteria and their toxins is one of the principal reasons for the undeniable superiority of breast-feeding over bottle-feeding. The sterilization of a contaminated milk, while lessening the danger which arises from continued growth of organisms, does not destroy the poisonous effects of the toxins already formed. Sterilization or pasteurization, therefore, does not do away with the necessity of using the strictest precautions in the collection and handling of the milk. Milk is one of the most favorable culture-media for bacteria. The conditions under which it is obtained make it peculiarly difficult to prevent it from becoming infected. The use of any preventive is absolutely unjustifiable in milk that is to be used for feeding of infants. The mortality and disease engendered by contaminated and adulterated milk, especially in warm weather, are enormous. The most careful modification of an impure supply, therefore, will give unsatisfactory results. The greatest advances in the subject of substitute feeding in this country are to be found in the progress which has been made in certain well-regulated farms by applying to every step in the collection and handling of milk the principles of cleanliness.

Bacterial Content of Milk.—Ordinary milk in the summer will contain from 500,000 to 20,000,000 bacteria to the cubic centimeter. With proper care this number may be reduced to from 200 to 10,000 bacteria to the cubic centimeter, and by modern methods of cooling and keeping the milk at a temperature of 40° C. or lower the growth of the few organisms that are usually present can be completely inhibited. Absolutely sterile milk has been produced at certain of the farms connected with the milk laboratories.

The bacteria usually present may or may not be pathogenic, but the bacterial count is the only reliable guide as to the care which is taken of the milk. A supply so carelessly obtained as to permit of any such development of bacteria as has been mentioned is dangerous, if not from the variety of the infecting organisms, at least as an indication that such a milk at any time may become contaminated by some bacteria that may prove a direct cause of disease. Practical experiment shows, moreover, that the products of the growth of bacteria which are classed as non-pathogenic are usually harmful to the infant, by causing intestinal indigestion and paving the way for direct infection by specific pathogenic organisms.

The methods employed in producing a pure, practically sterile, milk need not be described here in great detail. As has been stated, they are dependent upon strict cleanliness. The cow-barns should be arranged with facilities for the immediate and thorough removal of

manure, for the disinfection of the stalls, and the exclusion of flies. The feed should be in a separate building at a safe distance from the barn. The cows should be kept well groomed, and carefully wiped with damp cloths before each milking. The milk-pails should be sterilized, and the milkers obliged to wear clean caps and canvas suits, and to scrub their hands before each milking. The first of the milk from each teat should be discarded, as the bacteria penetrate into the lacteal ducts. After the milk has been drawn, it should be cooled and bottled at once. To do this to the best advantage the most hygienic dairies are provided with apparatus by which the milk can be cooled, aërated, strained, and bottled with only a few minutes' exposure to the air. The cream is separated by means of a De Laval centrifugal separator immediately after cooling and aëration, and thus has a distinct advantage over creams that have been obtained by gravity, in that it is much freer from dirt, most of which is separated from the milk in the separator, and from germs, owing to its shorter exposure. The storing of milk, keeping it surrounded with ice from the time it is bottled until used in the modifications, is the final step in the hygiene of the dairy.

All these precautions necessarily involve considerable expense in the running of a first-class dairy, especially as there are many other details to be observed, such as the periodic inspection of the milkers by a physician, of the herds by a veterinarian, the testing of the cows for tuberculosis by tuberculin injections, and the bacteriologic and chemical examination of the milk to maintain a standard quality. For the protection and safety of such a milk-supply the public must expect to pay higher prices than it has been accustomed to, and it rests largely with the physicians to impress upon it the desirability and even the necessity of procuring the best and cleanest milk possible for infants who must be reared on other food than that which is supplied by the mother.

The selection of the herd and the production of a practically sterile milk of constant composition, therefore, constitute the first essential in the modern method of substitute feeding. The second and no less important feature is the modification of the milk in its percentage compositions, so as to make it resemble more closely that of human milk; and, by such changes as may be indicated by the age, development, and the state of digestion of the infant, to adapt it to the requirements of the especial case.

The Theory of Percentage Modification of Milk.—The idea of modifying milk according to definite percentages of fats, sugar, and proteins in order to adapt it to the varying requirements of infant-feeding has very appropriately been called the American system of infant-feeding. It was in this country that it really had its inception, development, and practical application. The infant possesses a variable ability to digest fats, sugars, and proteins; when this function is disturbed, what may be spoken of as fat indigestion, sugar indigestion, and protein indigestion result. In one child it may

be the fat which causes the trouble; in another, the sugar, in still another, the protein material, while in a fourth all three elements may be at fault. Indigestion caused by an excess of any one of these elements, if not corrected, will in time result in disturbance of the whole function of digestion, in which all the elements of the food are incompletely digested. Undoubtedly many factors are influential in maintaining normal digestion and nutrition, about which little is known that is definite. Work is being done on the metabolism of infants and on intestinal flora and enzymes that promises much in the future, but has little practical bearing at present. The ideal system of substitute feeding must provide for percentages of fat, sugar, and proteins in any desired combination. Human milk is of very variable quality, and in practice we find that infants who are artificially fed also require very different percentage combinations according to their age, development, state of health, and many other conditions.

The earlier methods of simple dilution of whole milk with varying parts of water had as its principle the reduction of the proteins to a proportion similar to that which occurs in human milk. The dilution, however, affects the fats and sugars as well, and the general effect in comparison with human milk is seen in the following table:

	Fats	Sugar	Protein
Cow's milk	4.00	4.75	3.50
Cow's milk diluted 1 to 2,	1.33	1.58	1.16
Human milk	4.00	7.00	1.50

Obviously, simple dilutions of whole milk with water or any other diluent cannot produce a milk resembling mother's milk. Practically, babies seldom do well on such mixtures, for if the milk is sufficiently diluted to bring the proteins within the digestive ability of the child, the fats are too low for the proper nutriment of the body.

The next step in advance was the dilution of creams with water and the addition of milk-sugar to make up the deficiency of that constituent. The results obtained by this method may be illustrated as follows, using a 12 per cent. cream as an example:

	Fats	Sugar	Proteins
Cream	12	4.30	3.30
Cream diluted 1 to 2	4	1.43	1.10

In this way fats and proteins corresponding to the percentages in human milk are easily obtained, and the amount of sugar can be raised to any desired percentage by the addition of dry milk-sugar, or of sugar solutions in place of water.

This question here presents itself: What are the limitations to the combinations which are possible under the employment of this method of diluting creams? As the composition of cream varies according to the percentages of fat, we must agree on a fixed standard for the composition of the materials used. It is fully appreciated that the figures given below do not represent accurately the analyses

of all varieties of cow's milk, and that, therefore, in any given case there is always a possible error; but unless milk is analyzed daily, which is impracticable, we have no alternative but to adopt an average standard and let that be the basis on which we make our calculations. The average analysis, therefore, which we shall use, unless otherwise stated, may be tabulated as follows:

	Fats	*Sugar*	*Proteins*
Whole milk	4	4.75	3.50
Fat-free milk	0	5.00	3.60
Whey	0	5.00	1.00
8 per cent. cream	8	4.55	3.35
10 per cent. cream	10	4.45	3.27
12 per cent. cream	12	4.35	3.20
16 per cent. cream	16	4.15	3.05
20 per cent. cream	20	3.95	2.90

The following table shows the lowest possible proteins which may be obtained with fat percentages in our mixtures of from 1 to 4, in which creams of from 8 to 20 per cent. fat are used:

8 *per cent. cream gives with:*

Fat 1 per cent., lowest possible proteins of .... 0.47 per cent.
" 2 " " " " " " .... 0.85 " "
" 3 " " " " " " .... 1.27 " "
" 4 " " " " " " .... 1.70 " "

10 *per cent. cream gives with:*

Fat 1 per cent., lowest possible proteins of .... 0.38 " "
" 2 " " " " " " .... 0.67 " "
" 3 " " " " " " .... 1.00 " "
" 4 " " " " " " .... 1.34 " "

12 *per cent. cream gives with:*

Fat 1 per cent., lowest possible protein of .... 0.27 " "
" 2 " " " " " " .... 0.54 " "
" 3 " " " " " " .... 0.82 " "
" 4 " " " " " " .... 1.08 " "

16 *per cent. cream gives with:*

Fat 1 per cent., lowest possible proteins of .... 0.20 " "
" 2 " " " " " " .... 0.40 " "
" 3 " " " " " " .... 0.60 " "
" 4 " " " " " " .... 0.80 " "

20 *per cent. cream gives with:*

Fat 1 per cent., lowest possible protein of .... 0.15 " "
" 2 " " " " " " .... 0.31 " "
" 3 " " " " " " .... 0.46 " "
" 4 " " " " " " .... 0.62 " "

It is clear from the above table that in simple dilutions of cream we are limited in our protein percentages. To get low proteins with high fat percentages in our mixtures we must use concentrated creams. To get high proteins with creams of any strength, with the exception of 8 per cent. cream, we must add whole milk or fat-free milk to supplement the deficiency of proteins obtained from the diluted creams.

MODIFIED MILK

A modified milk is a milk to which anything has been added, or from which anything has been taken, by which its percentage composition is altered. Thus, the addition of water alone, or of sugar, or of cream, gives a different percentage combination. Unless an infant can digest whole cow's milk, percentage modification becomes an inevitable necessity in every case of substitute feeding. In practice it is simply a question of whether the physician shall prescribe accurately a modification, the percentage of which is approximately known, or shall use empirically mixtures of unknown percentages, subject to wide variations, without his knowledge. The modern, scientific, and approximately accurate system of substitute feeding has all the advantages of the older methods, and in a large measure is free from their objections. It is desirable for physicians to get into the habit of thinking and writing in percentages, as it leads to more exactness in the feeding and makes the experience gained in one case of value in the management of another.

The Calculation of Milk Modifications.—Any system involving the calculation of percentage combinations must be sufficiently elastic to allow considerable latitude in computations. To make the calculations practical to the busy practitioner, one must provide a method that shall be accurate, easily understood, and readily applied. To meet this requirement I have arranged a feeding card which can be conveniently carried in the pocket, and on which are given 30 different combinations of fats, sugar, and proteins, with the amounts, in ounces of cream, fat-free milk, lime-water, and boiled or distilled water, to be used in obtaining these combinations. The amounts of sugar to be added are expressed in measures, the standard of which is a tin dipper, obtainable at the milk laboratories, which contains $3\frac{3}{8}$ drams of milk-sugar, or approximately a level tablespoonful.

By referring to this card it is seen that it is so arranged that a physician may exercise a choice in the percentage of cream to be used, and can see at a glance what combinations are possible and what combinations impossible with the creams of different strengths. The calculations are made for 20-ounce mixtures. For 25-ounce mixtures the amount of each ingredient is multiplied by $1\frac{1}{4}$; for 30-ounce mixtures, by $1\frac{1}{2}$; for 35-ounce mixtures, by $1\frac{3}{4}$; and for 40-ounce mixtures, by 2.

The amount of lime-water, which has been calculated for 5 per cent. in each formula, may be increased at will by remembering that each additional ounce in a 20-ounce mixture increases it 5 per cent., and the number of ounces added must be subtracted from the amount of water used as a diluent.

For accuracy, the milk-sugar should be dissolved in a portion of the water, and then enough water added to make up the amount called for. The percentage of lime-water should not be confused with the alkalinity of the milk. A constant addition of 5 per

cent. of lime-water gives a variable percentage of alkalinity in the mixture, depending upon the number of ounces of milk and cream used. The more milk material used, the more acid there will be to neutralize the lime-water, and the less percentage of alkalinity there will be in the final mixture. The weakest formula, which calls for small quantities of milk and cream, will, therefore, have the highest percentages of alkalinity, and as these low percentage combinations are given in the early weeks of life and in cases of disturbed digestion, this relatively higher alkalinity is a distinct advantage.

No.	℞. 20-Ounce Mixtures. Percentage of:				Ounces of Cream				Ounces Fat-free Milk Used with Creams of:				Ounces		Milk-sugar Measures	Sugar Per Cent. Without Dry Sugar
	Fat	Sugar	Protein	Lime-water	10 %	12 %	16 %	20 %	10 %	12 %	16 %	20 %	Lime-water	Boiled water		
1	1.50	4.50	0.25	5	*	*	*	1½	*	*	*	0	1	17½	2	0.30
2	1.50	4.50	0.50	5	3	2½	2	1½	0	½	1	1½	1	16	2	0.70
3	2.00	5.00	0.25	5	*	*	*	2	*	*	*	0	1	17	2¼	0.40
4	2.00	5.00	0.50	5	*	3¼	2½	2	*	0	¾	1¼	1	15¾	2¼	0.70
5	2.00	5.00	0.75	5	4	3¼	2½	2	¾	1½	2¼	2¾	1	14¼	2	1.12
6	2.00	5.50	1.00	5	4	3¼	2½	2	1¾	2½	3¼	3¾	1	13¼	2¼	1.36
7	2.50	5.00	0.50	5	*	*	3¼	2½	*	*	0	¾	1	15¾	2¼	0.68
8	2.50	5.50	0.75	5	*	4¼	3¼	2½	*	¼	1¼	2	1	14½	2¼	1.06
9	2.50	6.00	1.00	5	5	4¼	3¼	2½	1	1¾	2¾	3½	1	13½	2½	1.42
10	3.00	6.00	0.50	5	*	*	3¾	3	*	*	0	¾	1	15¼	2½	0.79
11	3.00	6.00	0.75	5	*	5	3¾	3	*	0	1¼	2	1	14	2½	1.18
12	3.00	6.00	1.00	5	6	5	3¾	3	0	1	2¼	3	1	13	2¼	1.42
13	3.00	6.00	1.25	5	6	5	3¾	3	1¼	2¼	3½	4¼	1	11¾	2¼	1.72
14	3.00	6.50	1.50	5	6	5	3¾	3	2½	3½	4¾	5½	1	10½	2¼	2.04
15	3.00	6.50	2.00	5	6	5	3¾	3	5½	6½	7¾	8½	1	7½	2	2.73
16	3.50	6.00	0.50	5	*	*	*	3½	*	*	*	0	1	15½	2½	0.69
17	3.50	6.00	0.75	5	*	*	4½	3½	*	*	0	1	1	14½	2½	0.95
18	3.50	6.50	1.00	5	*	5¾	4½	3½	*	0	1¼	2¼	1	13¼	2½	1.31
19	3.50	6.50	1.25	5	7	5¾	4½	3½	½	1¾	3	4	1	11½	2½	1.78
20	3.50	6.50	1.50	5	7	5¾	4½	3½	2	3¼	4½	5½	1	10	2¼	2.15
21	4.00	6.00	0.60	5	*	*	*	4	*	*	*	0	1	15	2½	0.79
22	4.00	6.00	0.75	5	*	*	5	4	*	*	0	1	1	14	2½	1.05
23	4.00	7.00	1.00	5	*	*	5	4	*	*	1	2	1	13	2¼	1.42
24	4.00	7.00	1.25	5	*	6¾	5	4	*	¾	2½	3½	1	11½	2½	1.78
25	4.00	7.00	1.50	5	8	6¾	5	4	1	2¼	4	5	1	10	2½	2.13
26	4.00	7.00	2.00	5	8	6¾	5	4	3½	4¾	6½	7½	1	7½	2¼	2.73
27	4.00	7.00	2.50	5	8	6¾	5	4	6¼	7½	9¼	10¼	1	4¾	2	3.38
28	4.00	7.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1½	4.09
29	4.00	6.00	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1	4.09
30	4.00	5.50	3.00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	¾	4.09

For 25-ounce mixtures multiply amount of each ingredient by 1¼.
For 30-ounce mixtures multiply amount of each ingredient by 1½.
For 35-ounce mixtures multiply amount of each ingredient by 1¾.
For 40-ounce mixtures multiply amount of each ingredient by 2.
For 45-ounce mixtures multiply amount of each ingredient by 2¼.

* Combination impossible with strength of cream indicated.
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The following is an example of the way in which this card may be used: Suppose that it is desired to give a baby a mixture calling for 4 per cent. of fat, 7 per cent. of sugar, 1.25 per cent. of proteins, 5 per cent. of lime-water, and five feedings of eight ounces each. By referring to the table it will be seen that this corresponds to formula 24. Looking into the cream column, we see that it is impossible to obtain this combination with a cream of 10 per cent. fat, but it may be obtained with a cream of 12 per cent. fat. As 40 ounces of the modified milk is to be given to the baby in the course of twenty-four hours, it

will be necessary to double the quantity of each ingredient, and the calculation is readily made as follows:

12 per cent. cream	$6\frac{3}{4}$ ounces	$\times 2 =$	$13\frac{1}{2}$ ounces
Fat-free milk	$\frac{3}{4}$ "	$\times 2 =$	$1\frac{1}{2}$ "
Lime-water	1 ounce	$\times 2 =$	2 "
Boiled water	$11\frac{1}{2}$ ounces	$\times 2 =$	23 "
Milk-sugar	$2\frac{1}{2}$ measures	$\times 2 =$	5 measures

The chief difficulty associated with the *home modification of milk* lies in the uncertainty in regard to the percentages of the materials with which we are working. If creams of guaranteed strength can be purchased from milk laboratories or similar places, a home modification can be made with a considerable degree of accuracy. On the other hand, if we are dependent upon the use of gravity cream obtained from milk of uncertain composition, the strength of the cream can only be approximately estimated. We may, however, assume that a quart of milk which contains 4 per cent. of fat to start with, and which has been allowed to stand for a varying number of hours, will yield approximately the following percentages of fat in the different layers of the milk:

Cream, 10 per cent. in the upper 11 ounces after eight hours.
Cream, 12 per cent. in the upper 8 ounces after eight hours.
Cream, 16 per cent. in the upper 6 ounces after eight hours.
Cream, 20 per cent. in the upper 4 ounces after four to six hours.

If more cream is called for than can be obtained from one quart of milk, two must be provided, and the amount used should be from the mixture of the portions removed from each quart. If the milk is known to be rich in fat (5 per cent. or over), from two to three ounces more of the upper portions should be removed to obtain the percentage of fat indicated above, and if poor in fat (3 per cent.), about two ounces less than the specified amount should be taken. These statements are by no means absolutely accurate, since the result depends upon many varying conditions; but the figures represent a fair average of the investigations of Rotch, Holt, Chapin, the Walker-Gordon laboratory, and others.

Milk containing no fat, or, as it is called, fat-free milk, can be obtained from the lowest 8 ounces of the quart of milk which has been set for eight or more hours. The other materials used in the modification, that is, lime-water, distilled or boiled water, and milk-sugar, can be easily provided.

The percentage of sugar in any of these formulas can be varied at will by making use of the last column on the card, which shows the percentage of sugar contributed by the cream and fat-free milk, without the addition of dry sugar.

If, for instance, in formula 24, 6 per cent. of sugar is desired instead of 5 per cent. in a 20-ounce mixture, we calculate as follows: 6 (the desired percentage of sugar) minus 1.78 (the percentage of sugar contributed by the cream and fat-free milk) equals 4.22 (the percentage of sugar which must be added to the mixture). This is readily estimated by the formula $\frac{40\,L}{Q}$, in which L stands for the number of level table-

spoonful or measures of milk-sugar, and Q for the total number of ounces in the mixture.

The 4.32 per cent. of sugar is, therefore, calculated as follows: $\frac{40 \times L}{20} = 4.22$. L = 2.11 measures of sugar.

Whey-cream Mixtures.—The use of whey as a diluent in place of water in the combinations with low protein percentages has come into prominence recently, and has proved of much value in cases of difficult protein digestion. Its use is based upon the fact that the proteins of whey are chiefly lactalbumin and lactoglobulin—which may be spoken of as whey-proteins. They are present to the extent of 0.9 to 1 per cent. The whey-proteins are soluble proteins, are not coagulable by rennin or acids, and are, therefore, much easier to digest than the other proteins of milk—that is, than the casein or curd. If, therefore, whey is added to a milk modification in place of water, preferably in the combinations with low total proteins, we can increase the nitrogenous element without raising the percentage of casein. Such mixtures are now called by the name of *whey-cream mixtures* or *split-protein mixtures*.

It will help us to understand this better to recall the protein composition of cow's milk and human milk

	Total Protein	Whey-Protein	Caseinogen
Cow's milk	3.50	$\frac{1}{4}$ (0.87)	$\frac{3}{4}$ (2.63)
Human milk	1.50	$\frac{2}{3}$ (1.00)	$\frac{1}{3}$ (0.50)
Cow's milk, modified to give	1.50	$\frac{1}{4}$ (0.37)	$\frac{3}{4}$ (1.13)

The especial point to note is that the non-coagulable proteins, the whey-proteins, are proportionately small in cow's milk and large in human milk, while the coagulable protein, the caseinogen, is proportionately large in cow's milk and small in human milk. It follows that a modified cow's milk will contain relatively much more casein and much less whey-protein than a human milk of the same total protein composition. This doubtless is one, but not the only, reason why human milk is so much more digestible than cow's milk. It would appear theoretically that if cow's milk were modified so as to increase relatively the whey-proteins, keeping the casein low, as it occurs in breast-milk, we should have a milk that would be more easily tolerated in cases of difficult protein digestion. Practically this has been found to be true.

Whey contains approximately 1 per cent. of soluble proteins. Its use in place of boiled water will raise the percentage of whey-proteins without affecting the casein.

Method of Calculating Whey Mixtures from the Card.—The percentages of fats, proteins, and lime-water are calculated by the card. Three-fourths ($\frac{3}{4}$) of the protein in the formula chosen will be caseinogen, and one-fourth ($\frac{1}{4}$) whey proteins; that is,

Formulæ calling for 0.25 protein give approximately 0.20 caseinogen
" " " 0.50 " " " 0.40 "
" " " 0.75 " " " 0.50 "
" " " 1.00 " " " 0.75 "
" " " 1.25 " " " 1.00 "
" " " 1.50 " " " 1.20 "

To calculate the additional amount of whey needed to make the desired whey-protein percentage,

Let W = number of ounces of whey needed.
" Y = percentage of whey-protein desired.
" P = protein percentage in the card formula.
" Q = total number of ounces of mixture.

Then (1) $W = Q\left(Y - \frac{P}{4}\right)$.

The maximum in the percentage of whey-proteins in any formula is obtained when all the watery diluent is replaced by whey.

To calculate the sugar required beyond that contributed by the cream, milk, and whey,

Let S = percentage of sugar desired.
" L = number of measures, or level tablespoonfuls, of sugar to be added.
" Z = sugar percentage as given in last column of feeding card, *i. e.*, the amount contributed by the cream and fat-free milk.

Then (2) $L = \frac{Q\,(S - Z) - 5\,W.}{40}$

Example: ℞ Fat 4.00, sugar 7.00, whey-protein 0.90, caseinogen 0.75, lime-water 5.00. Amount, 20 ounces.

Solution: Formula 23 gives 0.75 caseinogen. Use 16 per cent. cream.

Cream	=	5 ounces
Fat-free milk	=	1 ounce
Whey	$= 20\left(0.90 - \frac{1.00)}{4}\right. =$	13 ounces
Lime-water	=	1 ounce
Milk-sugar	$= \frac{20\,(7 - 1.42) - 5 \times 13}{40} =$	1.16 ($1\frac{1}{6}$) measures

Whey is made by adding a preparation of liquid rennet to fat-free milk and allowing the mixture to stand until the casein, by process of coagulation, has been changed into paracasein. This is broken up with a fork. The paracasein contracts, and the whey is separated as a slightly turbid, straw-colored fluid. This must be strained and then heated to 155° F. to kill the rennin ferment, so that it will not coagulate the caseinogen of the cream used in the modification.

Calculation of Percentages of Starch.—In prescribing starch in an infant's food the percentage of starch should be calculated as accurately as that of any other element. This may be done by working with a decoction containing a standard amount of starch. Using Robinson's prepared barley flour or Robinson's groats (oatmeal flour), one may obtain a 3 per cent. solution of either form of starch by using two ounces of the flour to one quart of boiling water, cooking for thirty minutes, and adding enough water to make up the loss from evaporation. The formula for the calculation is:

$$\text{Number of ounces of starch solution to be used} = \frac{\text{percentage of starch desired} \times \text{total number of ounces in mixture}}{3}$$

Example: To obtain 0.75 starch in any 20-ounce mixture.

$$X \text{ (Number of ounces of standard starch solution)} = \frac{0.75 \times 20}{3} \text{ or 5 ounces.}$$

The five ounces of the 3 per cent. starch solution are, therefore, added at the expense of the water used as a diluent in making the mixture. The amount of starch that can be prescribed is limited by the number of ounces of diluent in the mixture. A percentage of 0.75 is efficient in mechanically breaking up the casein curd. A percentage of 1.25 need not be exceeded during the first year.

Calculation of Milk Modifications by Algebraic Formulas.—Westcott's mathematical formulæ for the calculation of modifications are the most elaborately worked out, and are much more accurate than those of earlier writers. As a scientific explanation of the mathematical principles involved they are invaluable, but for practical use they are unnecessarily complicated. Those which are based upon the use of creams and fat-free milk, however, are not difficult to understand, and for the benefit of those who prefer this system of calculation they may be concisely stated:

Let F = the prescribed percentage of fat.
S = the prescribed percentage of milk-sugar.
P = the prescribed percentage of proteins.
C = the total quantity of cream in ounces.
M = the total quantity of milk in ounces.
W = the total quantity of water in ounces.
L = the total quantity of dry sugar in ounces.
Q = the total quantity of mixture.
a = the known percentage of fat in cream (p. 173).
b = the known percentage of proteins in cream (p. 173).
b^1 = the known percentage of proteins in fat-free milk.

Then:

$$\text{Ounces of cream (C)} = \frac{Q\,F}{a}$$

$$\text{Ounces of fat-free milk (M)} = \frac{Q\,P - b\,C}{b^1}$$

$$\text{Measures of milk-sugar (L)} = \frac{Q\,S - 4.75\,(M + C)}{40}$$

$$\text{Ounces of water (W)} = Q - (C + M)$$

Method of Calculating Approximately the Percentage Composition of a Food from Known Amounts of Ingredients Used.—It is often desirable to be able to estimate the percentage value of the food an infant has been receiving in order to form an intelligent opinion of its digestive capacity. The principle by which this is done is not difficult to understand.

Let C = number of ounces of cream used.
" M = number of ounces of fat-free milk used.
" L = number of measures of milk-sugar (or level tablespoonfuls).
" Q = total quantity of mixture in ounces.

$$\text{Then (1) Fat percentage} = \frac{C \times \text{fat percentage of cream}}{Q}$$

$$\text{(2) Protein percentage} = \frac{3.50\,(C + M)}{Q}$$

$$\text{(3) Sugar percentage} = \frac{4.75\,(C + M) + 40\,L}{Q}$$

If whole milk is used in place of fat-free milk, add to the quotient in (1) the amount of fat contributed by the whole milk, M^1 standing for number of ounces used; *i. e.*,

$$(4)\ \text{Fat percentage in milk}\ \frac{M^1 \times 4}{Q}$$

Example: A 20-ounce mixture consists of 7 ounces of 10 per cent. cream, 2 ounces of fat-free milk, 1 ounce of lime-water, 10 ounces of boiled water, 2¼ measures of sugar.

$$\textit{Solution:}\ \text{Fat percentage} = \frac{7 \times 10}{20} = 3.50 \text{ per cent.}$$

$$\text{Protein " } = \frac{3.50\,(7 + 2)}{20} = 1.57 \text{ per cent.}$$

$$\text{Sugar " } = \frac{4.75\,(7 + 2) + 40 \times 2\frac{1}{4}}{20} = 6.63 \text{ per cent.}$$

The fat percentage of cream must be calculated by reference to the cream table on p. 173.

The Mixing of Milk and its Administration.—The principles of modifying milk which have been described need be understood only by the physician. The directions which are given to the mother can be very simply stated, and require only moderate intelligence to carry out. She is told to take the required number of ounces of cream, fat-free milk, and lime-water, and to mix them in a large sterilized vessel. The milk-sugar is then measured, and boiled or distilled water added up to the amount called for. As the milk-sugar does not go into solution readily in the cream and milk, the precaution of dissolving it in the water first is important. The sugar solution thus obtained is added to the mixture of cream, fat-free milk, and lime-water, and the whole is poured into another vessel, once only, to insure thorough admixture of all the ingredients. It is then divided into as many nursing bottles as there are feedings in the twenty-four hours, each bottle containing the prescribed amount for one feeding. The bottles are then tightly stoppered with clean absorbent cotton and placed at once in the ice-chest.

If the milk is to be pasteurized, the bottles are placed in a sterilizer filled with cold water up to the level of the milk. The temperature of the water is to be raised to about 3° F. above that at which the milk is to be pasteurized, covered with a hood, and kept at a constant point for twenty to thirty minutes. The bottles are then removed, cooled quickly in running water, and placed on ice.

Before each feeding the milk is heated again in hot water until its temperature has been raised to 100° F.; the stopper is removed, and a clean sterile nipple applied. The milk may be kept warm by wrapping the bottle in a napkin. As a rule, fifteen to twenty minutes are sufficient to allow for the nursing period. The bottle should invariably be held by the nurse or mother in such a way that the neck is kept constantly filled, the baby remaining on its back in its crib.

The custom of propping the bottle up so as to leave the nipple within reach of the child should be absolutely forbidden.

Especial care should be taken to explain what is meant by "cream" and "fat-free" milk, and in directing her as to the number of quarts of milk to be ordered to secure the quantity of cream needed (p. 176). She should be impressed with the fact that the number of ounces of "cream" removed from each quart of milk includes usually what is visible as cream, and also a certain number of ounces of milk beneath the cream line. Great errors in modification arise from neglect of this precaution. The cream may be removed by a siphon, by which the lowest, or fat-free, milk is first drawn off, then the middle milk, which is put aside, leaving the required number of ounces of "cream" in the jar. The cream dipper is a somewhat simpler device for removing the cream, but when the process of modification must be made very simple, as in dispensary practice, it will suffice to direct that the required number of ounces of the top milk be poured off. A graduated glass and a milk thermometer, in addition to the nursing bottles, are the only apparatus which are essential. A sugar measure and a sterilizer are convenient to have. A double boiler, however, will serve the purpose of pasteurization. The nipples vary greatly in shape. The essential point is to provide one which will not collapse, can be easily turned inside out and scrubbed, and has a perforation of the size appropriate for the individual case. Too large or too small holes are equally objectionable. Many nurses prefer to buy blind nipples and pierce holes in them with red-hot needles. In this way one soon learns the size which is best suited to the baby. The nipple should be scrubbed with borax and washed in boiling water after each nursing, and then kept in a solution of boric acid. It is wise to keep several nipples in use, so that the baby may not become fixed in its preference for any particular one. Nipples with tubing attached are a great source of danger, owing to the impossibility of keeping them clean.

In the home modification of milk, therefore, there are five things to be taken into consideration (pp. 163, 165, 170): (1) The selection of a proper milk-supply; (2) the separation of the cream and fat-free milk (pp. 169, 176); (3) the selection of the combination which is suited to the individual child (to be described later, pp. 184 to 188); (4) the calculation of the combination desired (p. 175); and (5) the determination of the number of feedings, the intervals between feedings, and the amount of each feeding (to be described later, p. 185).

The Laboratory Modification of Milk.—The development of the percentage system of feeding has been brought about through the establishment of the so-called milk laboratories, in which Dr. Thomas Morgan Rotch, of Boston, has been the moving spirit. Most of the principles of home modification which have been explained have emanated from the laboratories—that is, are adaptations of laboratory methods. The laboratories are under the control of the Walker-Gordon Company. Starting in Boston in 1891, branches have been

established in New York, Philadelphia, Chicago, Baltimore, Buffalo, Cincinnati, Cleveland, Detroit, Grand Rapids, Milwaukee, Pittsburg, St. Louis, Washington, Montreal, Ottawa, Toronto, Plainsboro, N. J., and London. In connection with the laboratories are milk farms where the fresh, clean milk and cream are produced under the most scientific conditions known. In this way the most important requisite of successful feeding is secured. The laboratory itself is a center to which the physician may send his prescriptions for any percentage modification of milk desired, and from which the milk may be dispensed with greater accuracy and less inconvenience than in home modification. It prepares and delivers whatever the physician orders. It bears a relation to the physician analogous to that of a drug-store. It is responsible only for the purity of its milk-supply and the accuracy of its modifications. Whether or not the milk thus modified and dispensed agrees with the child involves a question of responsibility entirely outside the sphere of the laboratory. The principles of the modifications are essentially the same as in home modification, but the limits of error are much less because of the excellent character and stable composition of the materials used. As a matter of convenience to the physician and mother it is, of course, of great service, and simplifies many of the problems connected with artificial feeding. No calculation on the part of the physician is necessary, and no preparation of food on the part of the mother or nurse. The physician expresses in percentages of fat, sugar, proteins, and alkalinity what he desires, and the laboratory makes its computation.

The following prescription blank shows the latitude one is allowed in varying the composition of an infant's food in laboratory modifications:

℞.		Per Cent.
Fats		
Carbohydrates	Lactose (milk-sugar)	
	Maltose (malt-sugar)	
	Sucrose (cane-sugar)	
	Dextrose (grape-sugar)	
	(a) Starch	
(b) Proteins	Whey	
	Casein	
(c) Lime-water	Per cent. of milk and cream	
	Per cent. of total mixture	
(d) Sodium bicarbonate	Per cent. of milk and cream	
	Per cent. of total mixture	
(e) Lactic acid bacillus	1. To inhibit the saprophytes of fermentation	
	2. To facilitate digestion of the proteins	

EXPLANATORY

(*a*) It requires 0.75 per cent. starch to make the precipitated casein finer.

(*b*) In case physicians do not wish to subdivide the proteins, the words "whey" and "casein" may be erased.

(*c*) It requires 20 per cent. of the milk and cream used in modifying to favor the digestion of the proteins; 50 per cent. of the amount of milk and cream used suspends all stomach action on the proteins; 5 per cent. of the total mixture gives a mild alkaline food.

(*d*) It requires 0.68 per cent. of the milk and cream used in modifying to favor the digestion of the proteins; 1.7 per cent. of the amount of milk and cream used suspends all stomach action on the proteins; 0.17 per cent. of the total mixture gives a mild alkaline food.

(*e*) Percentage figures represent the per cent. of lactic acid attained when the food is removed from the thermostat. When the lactic acid bacillus is used to facilitate digestion of the proteins, this is the final acidity, as the process is stopped by heat at this point. When the lactic acid bacillus is used to inhibit the growth of saprophytes, the acidity may subsequently increase to a variable degree, as the bacilli are left alive; 25 per cent. lactic acid just curdles milk; 50 per cent. gives thick, curdled milk; 75 per cent. separates into curds and whey.

The laboratory clerk calculates from tables the amount of cream, fat-free milk, lime-water, water, and milk-sugar, etc., necessary to make the desired modification. These directions are handed to the modifying clerk, who mixes the various ingredients and then subdivides the total amount into separate tubes, each containing the maximum quantity to be given at one feeding. These tubes are stoppered with sterilized aluminum caps, placed in baskets, and kept at a temperature of 38° F. until delivered. A fresh bottle is used for each feeding, the milk being first heated to a temperature of 98° to 100° F.

The modified milk may be ordered in separate tubes as described, or, by a recent innovation, in quart jars, which reduces the cost about 50 per cent., and, in places where laboratories are established, brings the expense within the means of practically every one who is sufficiently prosperous to employ a private physician.

In out-of-town deliveries the milk is packed in ice-boxes and can, therefore, be shipped long distances. Whole milk and modified milk may be ordered for ocean voyages. These are especially prepared and sealed with paraffin, but no preservatives of any sort are added. Three or four weeks' supply may thus be provided.

If no request to the contrary is made, the mixture will be put up by using 16 per cent. centrifugal cream, but if the physician has any objection against centrifugal cream, he has only to request that a gravity cream be used instead. I do not believe that there is any rational argument against the use of centrifugal creams in laboratories where the cream is separated immediately after the milk has been

aërated and cooled, and where the strength has been accurately determined. In home modifications commercial separator creams should not be used. The cream should be obtained from fresh milk by the gravity process, according to the rules which have been described (p. 176).

The milk is pasteurized or not as the physician chooses to direct. There is a growing tendency to use unpasteurized milk, and to make more and more sure that the milk at the beginning is clean and comparatively free from dirt and bacteria, and to use more care to keep it at a constantly low temperature, so as to inhibit the growth of the few bacteria that are invariably present in fresh, unheated milk. If any question exists as to the purity of the milk-supply; if there is any tendency to diarrhea; or if the weather is warm, as in late spring or summer, it is much safer to heat the milk to 155° F. This temperature is now used in preference to higher ones, as has been stated, as it is nearly as efficient as a means of killing developed organisms and is so low that no chemical change in the milk is made. The various ferments occurring in milk are also unaffected by this degree of heat.

If cereal solutions are to be added to the milk, the physician simply states the kind and percentage of starch desired in each tube, and in making up the mixture the cereal is made to replace the same quantity of water, so that the fat, sugar, and protein percentages are not altered.

If it is desired to split the proteins, altering the proportion of the whey-proteins and caseinogen, as described above, we can do so with fewer restrictions, as the use of very concentrated creams allows a much greater variation of combinations. The combinations of whey-proteins possible when prescribed from the laboratories are seen in the following table of whey-cream mixtures. Any percentage of fat from 1 to 4, and any percentage of sugar from 1 to 7, may be had in combination with—

Whey-proteins Per Cent.	Caseinogen Per Cent.
0.25	0.25
0.50	0.25
0.75	0.25
0.75	0.50
0.80	0.25
0.80	0.50
0.80	0.75
0.80	1.00
0.80	1.25

The next change would be to a total protein of 2 per cent., which contains proportions present in whole milk, that is, whey-proteins ($\frac{1}{4}$) 0.5 per cent., caseinogen ($\frac{3}{4}$), 1.5 per cent.

RULES FOR FEEDING

Equally important with the question of the composition of the food is, as in the case of breast-feeding, the regulation of the number of feedings, the intervals between feedings, and the quantity at each feeding. The following table of Rotch gives these rules, together

with the appropriate modification at different ages, both in the plain cream mixtures and the whey-protein mixtures. It should be strictly borne in mind that these data apply only to the *average healthy* infant. They do not necessarily hold in cases of disturbed digestion, as will be explained later. They are given here only as a general guide, and should be varied according to the individual requirements. In very vigorous infants the quantity at each feeding may be from one-half to one ounce more than is given in the schedule.

Age	Fat	Sugar	Proteins	Proteins if Split		Amount at Each Feeding in:		Intervals between Feedings in Hours	Number of Feedings in Twenty-four Hours
				Whey-proteins	Caseinogen	Ounces	Cubic Centimeters		
Premature	1.00	4.00	0.25	0.25	0.25	$\frac{1}{8}$–$\frac{3}{4}$	4–25	1–1½	24–18
	1.50	4.50	0.25	0.50	0.25	..	4–25	..	..
At term	2.00	5.00	0.50	0.50	0.25	1	30	2	10
End of 2d week	2.50	5.50	0.50	0.50	0.25	1½	45	2	10
End of 3d "	3.00	6.00	0.75	0.75	0.25	2	60	2	9
End of 4th "	3.50	6.50	1.00	0.80	0.50	2½	75	2	8
End of 6th "	4.00	7.00	1.00	0.80	0.60	3	90	2½	8
End of 8th "	4.00	7.00	1.25	0.80	0.75	3½	105	2½	7
End of 12th "	4.00	7.00	1.50	0.80	1.00	4	120	2½	7
End of 4 months	4.00	7.00	1.50	0.80	1.25	4½	135	3	6
End of 5 "	4.00	7.00	1.75	..	..	5½	165	3	6
End of 6 "	4.00	7.00	2.00	..	..	6	180	3	6
End of 8 "	4.00	7.00	2.50	..	..	7	210	3	6
End of 9 "	4.00	7.00	3.00	..	..	8	240	3	6
End of 10 "	4.00	6.00	3.00	..	..	8	240	3	6
End of 11 "	4.00	5.00	3.00	..	..	10	300	3	5
End of 12 "	4.00	4.75	3.50	..	..	10	300	3	5

It has been found by experience that it is not good practice to start a new-born infant upon modified milk of the same composition as human milk. The most frequent mistake made is to give a milk of too high percentages. If there is any one rule which is more important than others, it is to begin the feedings on low modifications and then, gradually advancing one element after another, to increase the strength until, by the eleventh or twelfth month, the infant is getting whole milk. The rapidity with which this can be done varies according to the idiosyncrasies of the infant. Each child is a problem by itself, and no greater mistake can be made than to assume that all babies of an age require the same strength of food. There are cases in which whole milk cannot be digested until the fourteenth or fifteenth month or even later unless water or cereals are added, in which case one is really giving a modified milk with reduced percentages. The quantity of food taken often varies within wide limits, so that no arbitrary rules of feeding should be the standard by which to judge an infant's progress, but, as has been stated, one must be guided by the state of its digestion and weight development. If a baby at birth is

started on a carefully modified milk made from fresh, clean cow's milk, and if it is intelligently observed, one will rarely fail to pull it through its critical first year; but there are difficult cases which require much patience and careful variations in the composition of the milk from time to time.

For the first twenty-four to thirty-six hours a dram or two of a 5 per cent. lactose solution every hour and a half or two hours usually suffices. It is then wise to begin at once on a modified milk.

The *fat* should be from 1.5 to 2 per cent. during the first week, increasing it to 2.5 per cent. in the second week. By the end of the third week 3 per cent. fat may be tried, and at the end of a month it may be possible to give a 3.5 per cent. fat. It is often advisable not to start the child on a 4 per cent. fat until the sixth or eighth week. It is usually not wise to go higher than this. Certain infants digest fats with difficulty. In such cases a percentage of 3 or 3.5 should not by exceeded, but an effort should be made to give from 0.25 to 0.5 per cent. higher proteins than is called for in the table.

There is at present a strong feeling against high fat percentages. It is maintained that too much importance has been attached to the proteins as a cause of indigestion in infants. It appears to some of us, however, as if this prejudice against fats and in favor of fat-free mixtures with high proteins may be carried too far. The practice of giving 4.5, 5, and even 6 per cent. of fat to satisfy a mother's desire to have her baby much above the weight of the average healthy infant undoubtedly had much to do with the reaction against high fats. Serious cases of intestinal intoxication have resulted from such methods of feeding, and rapid improvement is shown in this class of cases when fats are rigidly excluded from the food and the proteins raised. On the other hand, the argument in favor of very high proteins has undoubtedly been carried too far. One should keep in mind three general principles of feeding which can be easily demonstrated clinically If in the average feeding case the fats are kept very low, relatively high proteins can be given without disturbance. If the proteins are kept very low, relatively high fats can be given. High fats together with high proteins, continued for a considerable period, almost invariably impair the functions of digestion and eventually lead to serious degrees of malnutrition.

The first requirement of infant-feeding is to supply a food which is within the infant's power to digest. The next point is to see that the balance between the food elements is such that there shall be a normal weight development, neither greatly above nor greatly below the standard of the average healthy child as given in the weight chart (p. 153). A fat-free diet is likely to be easily digested, but does not supply the elements necessary to normal development. Rachitis is particularly liable to result after months of such feeding. Too high fats with too low proteins, on the other hand, tend to make a baby at first fat, but undermine digestion and eventually produce a very severe and intractable condition of malnutrition with anemia.

Babies differ to an extraordinary degree in their food requirements and capacity for digestion. A percentage of fat that is high for one infant is exactly suited to the needs of another. The same is true of sugars and proteins. The quantity of food taken in twenty-four hours is subject to a similar variation in different infants. It is these idiosyncrasies of digestion and nutritive needs which make the successful feeding of difficult cases a question not of following a printed schedule of rules, but one of judgment. One must approach the subject with a mind free from bias, studying each case in reference to its individual needs. Working out the modifications on a percentage basis simply means accuracy of method. What percentages are best suited to the case must be determined by the result of experiment.

The *sugar* percentage can be pushed up even more rapidly than the fat. We begin with 5 per cent. in the third week, raise it to 6 per cent., and by the end of six weeks to 7 per cent., which represents the maximum. The sugar of milk is the most satisfactory sugar to use in the average case. Where there is a pronounced tendency to flatulence and constipation or to sour-smelling stools one may with advantage substitute malt sugar, either in the form of maltose or of some of the proprietary malt foods.

The management of the *proteins* presents the greatest difficulty. It is disastrous to give too high proteins, and it is dangerous to keep them too low for too long a period. Most physicians err in giving percentages at the beginning so high as to cause disturbances of digestion and of nutrition. Those of us who appreciate how great is the danger of high proteins have to guard against the habit of keeping them low for so long that the nutrition of the child suffers. Obviously, success comes most frequently to him who can discriminate nicely between the two extremes. The ability of infants to digest the proteins of milk varies so greatly that one hesitates to give definite statements as to the desirable percentages at different ages. It is safest to begin low and increase very gradually by percentages not greater than 0.25. A percentage of 0.5 will last for a week or two. In the third week it may be raised to 0.75 per cent., and if, at the end of a month, 1 per cent. has been reached, we are doing very well. For the second and third months 1.25 per cent., and 1.5 per cent. for the fourth month, are generally sufficient. Two per cent. of proteins at the fifth or sixth month is desirable if it can be digested, and is continued until the eighth or ninth month, when, in healthy babies, it is well to add barley-water* or oat-water† in place of the boiled

* The rules for making cereal decoctions are as follows:

Barley-water.—Put one-half ounce of Robinson's prepared barley into one quart of boiling water and cook for twenty minutes. Add enough water to make up what has evaporated, and strain while hot. This gives approximately 0.75 starch.

Barley-jelly.—Put two ounces of Robinson's prepared barley into one quart of water and boil for twenty minutes. Add enough water to make up what has evaporated, and strain while hot. In barley-jelly made in this way there is approximately 3 per cent. of starch. Use a graduate and measure as for fluidounces.

† Oatmeal water and oatmeal jelly may be made in the same way as barley water and barley gruel, using Robinson's prepared oatmeal flour.

water used as the diluent. Cereals serve to break up the curds, and also provide the element of starch which the child at this age begins to need for its proper nutrition, but do not lessen the necessity of careful regulation of the other ingredients. The thickness of the barley-water and oat-water can then be gradually increased, while the proteins are raised to 2.5 and then 3 per cent. The higher the proteins are raised, the less is the amount of the diluent, so that unless the cereal solution is increased in strength, there will be a continual decrease in the percentage of starch contained in the modification. With the increase in the amount of starch the percentage of milk-sugar is gradually diminished to that of whole milk, and the question of feeding then becomes that of the second year of life.

The amounts at each feeding, the intervals and number of feedings, need no further explanation than that given in the above table, except to impress upon the physician that they are only approximate; in some cases more, in others less, than the quantities suggested will be found desirable. No radical increase in the quality and quantity of the milk beyond that recommended can be made without running the risk of overfeeding and sometimes of dilatation of the stomach.

CASES OF DIFFICULT FEEDING

The difficult cases of feeding are, for the most part, those in which gastric and intestinal indigestion have continued uncorrected for a considerable time. The difficulty of reëstablishing normal digestion is just about in proportion to the length of time the functions have been abused. The power to assimilate food and to eliminate the waste-products of metabolism is often profoundly affected. Extreme malnutrition and anemia result and are not easily controlled. In the management of such cases the rules for feeding the healthy baby are subject to wide changes. It is almost impossible to give general rules to cover such cases. The feeding of each infant is a particular problem to be worked out according to its condition. A careful history of its previous feedings will perhaps make clear the kinds of food which have failed, and so give some indications of what lines to follow.

The symptoms may be much the same for many different kinds of indigestion. A baby who has had excessive fats must be kept upon a fat-free diet for a longer time than the one who, reared upon a food such as condensed milk, is suffering from overfeeding of carbohydrates. The baby who suffers from colic and malnutrition from low fats and high proteins will readily adapt himself to moderate percentages of fats if the proteins are temporarily reduced, changed to the split whey-proteins, or peptonized.

The quantity of food required cannot always be judged by the weight of the child. An eight-months'-old infant weighing eight pounds requires a larger twenty-four-hour amount of food than a two-weeks'-old child of the same weight, but less than the normal baby of eight months. Owing to the great difficulty in determining at once the

percentage composition of the food needed it is best to regulate the strength of the food in cases of difficult feeding according to the standard set for new-born infants. The condition of the digestion, the evidence of hunger, and the gain in weight will be the guides by which we may determine how rapidly the strength of the food may be increased. A very weak food that can be digested will make a child gain in weight, when it is losing or making no progress in weight development upon a strong food which is beyond its capacity to digest. When the limit of gain on a given mixture has been reached, one or more of the ingredients of the milk must be raised. To manage such cases successfully requires constant supervision and good judgment.

We have no reliable way of increasing the digestibility of the fats, except by reducing the percentage, which, if long continued, results in malnutrition. One should remember that the indigestion of the fats is often secondary to the infant's difficulty in disposing of the carbohydrates and proteins. Measures taken to correct the indigestion of the latter elements will often correct the trouble with the fats. The management of the carbohydrates may be found in the substitution of a malt-sugar for milk-sugar, such as Liebig's or Loeffland's malt soup extracts, or in replacing a part of the sugar percentage with a starch decoction, in the form of barley- or oat-water. These cereal decoctions are also of great value in causing the casein of the milk to be precipitated in small curds, which are thus not only more easily digested themselves, but the fat which is incorporated in the curd in the process of coagulation is more readily acted upon by the fat-splitting ferments of the intestinal secretions.

The influence of the alkalis, such as lime-water, bicarbonate of soda, and citrate of soda, described on p. 183, should be carefully noted. Variations in the percentage of alkalinity and in the kind of alkalis used, will often help to solve a difficult problem of feeding.

The use of ripened or lactic acid milk is still in an experimental stage. At present its value seems to be greatest in the cases of putrefactive or fermental diarrhea, and to bridge over the interval between the period of starvation and milk feeding in the infectious diarrheas. It is worthy of a trial, but can hardly be called a specific in the treatment of these diarrheal diseases.

The use of whey-cream mixtures in these severe cases of malnutrition with indigestion is to be strongly recommended. I have tried them in many cases, part of which have been reported, with better results than by the use of the plain cream mixtures. If the fats are started, irrespective of the age of the child, at 2 per cent., the sugar at 5 per cent., and the caseinogen at 0.25 per cent., the whey-proteins can be rapidly increased to the maximum of 0.8 per cent. This weak mixture should be continued until the symptoms of indigestion have disappeared or been greatly alleviated. This is the first object to be sought, even at the cost of further loss of weight. It provides the element of rest which is essential to the restoration of the normal functions of the digestive apparatus. We

may then, by slow but progressive changes in the percentages of the fats, sugar, and caseinogen, and by increase in the quantity of food, direct our efforts toward the reconstruction of the tissues, keeping in mind, as the limits to be attained, the theoretic basis of feeding given above.

Occasionally, in very difficult cases, in addition to the modification of the milk as suggested, partial peptonization of the mixture is a valuable temporary expedient, principally to lessen the tax on the function of gastric digestion. The contents of a peptonizing tube may be dissolved in as many teaspoonfuls of water as there are feedings. One teaspoonful of this solution is added to each bottle of milk and heated at a temperature of 100° F. for ten or fifteen minutes just before the feeding. Peptonization of the milk does not in any way lessen the importance of a proper modification. It is a fair statement to make, however, that the more familiar and experienced one becomes with the principles of percentage modification of milk, and of infant-feeding in general, the less frequently will one resort to peptonization.

When satisfactory results are not obtained after a reasonable trial of the various resources of substitute feeding, a wet nurse should be obtained. A few weeks of breast-milk feeding will often pave the way for the successful feeding by substitute methods. A great responsibility rests upon the physician to see that these extreme cases of malnutrition and indigestion are not exhausted by too prolonged experimentation with the various modifications of cow's milk.

There are certain symptoms pointing especially to gastric indigestion, such as vomiting of food or water, belching gas, a coated tongue, and sour breath. Symptoms such as colic, flatulence, abdominal distention, diarrhea, constipation, and stools with curds, mucus, or blood, point to intestinal derangements. Sometimes it is one element, sometimes several, which either cause or aggravate these symptoms; we cannot always determine which one is responsible. As a rule, a sour breath and vomiting of strongly acid stomach-contents indicate too high fats, but excessive sugar or proteins may produce the same results. Vomiting very shortly after feeding and regurgitation are often due to overdistention of the stomach from too large a quantity of food. Colic and stools with curds usually indicate too high proteins, sometimes too high fats. Curds in the stools do not necessarily indicate protein indigestion. Talbot has recently demonstrated their composition to consist chiefly of fat, in the form of soaps, and casein in about the same proportion as they occur in the food that is given. The very small soft curds are mostly fats.

An infant who has been fed upon a very weak mixture for too long a period may develop what may be described as a starvation diarrhea. The stools are frequent, slightly loose, and contain curds and sometimes a little mucus. There is no fever. There are unmistakable signs of hunger. In these cases the movements rapidly become normal as the strength of the food is increased.

Constipation may be due to too low fats, or to milk which, in its

total solids or twenty-four-hour amount, is below that which is needed by the infant. If there is no indigestion, failure to gain in weight is probably due to the fact that the milk combination as a whole is too weak, or the quantity given in the twenty-four hours is deficient. On the other hand, too much of a proper modification, or too frequent feedings, are often responsible for retardation of the weight development.

Finally, it is important to remember, when judging of results, that failures in feeding are not always due to the food itself. There are a large number of causes, quite independent of the milk and its modifications, that are responsible for conditions characterized chiefly by gastric and intestinal disturbances and loss of weight. Cleft-palate, adenoids, the various forms of stomatitis, and difficult dentition are many times the causes of the refusal of part or all of a feeding, and for variabilities in appetite and freedom of nursing which may hastily be attributed to the milk itself. Too rapid and frequent nursing, or too large quantities at a feeding, may be followed by vomiting, which may unreasonably be laid to the bad quality of the milk or to its percentage combination. Again, vomiting, diarrhea, and loss of weight may be wholly symptomatic of acute or chronic diseases. Many of the forms of anemia and leukemia, bacterial invasion of various parts of the body, chronic diseases, such as tuberculosis and syphilis, autointoxications, malformations of the gastro-intestinal tract, inhalations of poisoning from arsenic, sewer-gas, carbon monoxid, and, not least by any means, unhygienic surroundings and neglect, are all to be excluded as primary factors in the production of indigestion and malnutrition when a baby is first seen. In any of these instances the regulation and adaptation of the food become the first indication of treatment, but the prognosis is always that of the exciting cause, and all efforts at feeding may prove futile. In pure feeding cases, however, in which the indigestion and malnutrition are directly dependent upon violation of the rational dietetics of infancy, there is no infant, not actually moribund, that is not worth the effort to save, and in a great majority of these cases one may justly take a most hopeful view as to the ultimate prognosis.

The treatment of the especial diseases and disorders of the gastro-enteric tract will be considered in another chapter.

FEEDING OF PREMATURE INFANTS

The feeding of premature infants follows the same general principle as has been outlined. There are, however, several differences to be taken into account. Owing to the very small capacity of the stomach, the quantity should be less than in full-term babies, and should be given more frequently. For the first few days the infant should be fed hourly day and night, from one to two teaspoonfuls. The intervals then may be increased to one and one-half hours, and the number of feedings diminished to 18, and then to 12, the quantity at each time being gradually raised to one ounce. The percentage composi-

tion of the food is generally best started at: fat, 1.50; sugar, 4.50; and proteids, 0.25, or, if split, whey-proteins, 0.25, and caseinogen, 0.25. The strength of the food must be increased very cautiously. Progress will be slow until the full nine months have been completed, after which the gain is usually more rapid. If the baby will not nurse from the usual nipple, a medicine-dropper may be used to administer the milk, or a Breck feeder will serve the same purpose, and also train it in the function of sucking.

Substitute feeding should never be employed for premature infants when breast milk can be obtained. The mortality is much greater, and the normal development, even in the cases that do well, is distinctly retarded.

PROPRIETARY FOODS FOR INFANTS

The commercial or proprietary foods for infants can never be looked upon as substitutes for breast milk, any more than milk-sugar can be so considered. There is not one preparation in the market that, alone, without the supplementary use of cow's milk, can be considered a suitable food. If milk is to furnish the basis of the feeding, its proper modification and adaptation to the infant's needs are imperative, whether used with a patent food or with milk-sugar. The consensus of opinion of pediatrists in this country is strongly against the use of such articles as inadequate, unnecessary, and often dangerous. It is a responsibility which no reputable and progressive physician should assume to direct a mother to buy a certain food and follow the directions on the can. If such preparations are to be employed at all, the physician should direct their use in combination with proper percentage modifications of cow's milk.

The foods which are intended to be used without the addition of cow's milk are deficient in animal fat and proteins and contain an excess of carbohydrates. Their temporary usefulness in acute illness, when the stomach will not tolerate milk in any form, may be admitted, but their use for more than a few days, or, at the most, weeks, is greatly to be deprecated.

Many of the most popular brands are derived from cereal flours. They consist of more or less completely converted starches in the form of dextrin, dextrose, and maltose. They supply the carbohydrate element in the baby's food, and one must rely upon cow's milk to furnish the animal fat and proteins. They impart to a mixture their own peculiar taste and laxative properties, which may or may not be desired in a given case. Whether they cause rachitis, atrophy, and scurvy depends upon the mixture as a whole, rather than upon any deleterious action of the proprietary food itself.

Another class of prepared foods consists entirely of milk-sugar and peptonizing agents. If the peptonizing action is desired, it is best to obtain it directly by the use of peptonizing powders, and to add separately the carbohydrate in the form and percentage indicated in the case.

The condensed milks are of two kinds, sweetened and unsweetened. The former, contrary to the opinion generally held, often show a very high bacterial count. Both when diluted are deficient in animal fat and proteins, and, like the malt foods, are of doubtful value and should never be used for permanent substitute feedings.

The proprietary cereals, such as the barley and oatmeal flours, require cooking and have their distinct use whenever starch in the food is indicated. The proprietary beef foods are stimulants, rather than foods, and play an unimportant part as nutritives. They are inferior to freshly prepared broths and beef-juice.

A detailed consideration of these preparations is quite unprofitable. Their use tends to the neglect of the really vital questions concerned with the production of a pure, clean milk-supply and its intelligent modification, and is, therefore, to be discouraged.

FEEDING IN THE SECOND YEAR

In the last three months of the first year the infant has been gradually accustomed to starch in the form of barley-water and oat-water. As the percentage of proteins is raised to that of whole milk, the amount of the water used as the diluent decreases, and to maintain or increase the percentage of starch, the cereal decoctions should be added in the form of thick jellies. The time at which the healthy infant will digest whole milk is very variable—often not before the end of the twelfth, thirteenth, or fourteenth month. Many infants will require the combination of the modified milk even longer. This is especially true in infants with chronic gastric and intestinal indigestion and malnutrition, whose feeding has not been regulated until well toward the end of the first year. In these cases it is not a question of age so much as of digestion and nutrition that guides us in the question of food requirements.

In the second year there is often a tendency to constipation when the whole milk is given, so that the addition of cream to raise the fat from 4 to 5 per cent. is desirable. This is easily calculated by remembering that 2 ounces of a 10 per cent. cream, or $1\frac{1}{2}$ ounces of a 16 per cent. cream, to each 20 ounces, will give the necessary 1 per cent. additional fat. On the other hand, very rich milk may require dilution with water in the proportion of 1 to 5 or 6.

At the end of the thirteenth month one may also begin to accustom the child to solid food in the form of crumbs of bread which is at least twenty-four hours old. These can be soaked in the milk and fed with a spoon. One should begin with a piece about one-half-inch cube, and gradually increase to one- and then two-inch cubes, when the child's appetite can be taken as the indication for the amount to be given. It is not uncommon at first for solid food to cause choking, gagging, and often vomiting, in which case great care must be exercised in its use.

Five meals a day are generally needed from the twelfth to the fifteenth months, which may be arranged as follows:

7 A. M. : Whole milk.
10.30 " " : Whole milk, $\frac{2}{3}$; cereal jelly, $\frac{1}{3}$.
2 P. M. : Whole milk, $\frac{2}{3}$; cereal jelly, $\frac{1}{3}$.
5.30 " " : Whole milk.
9 " " : Whole milk.

The quantity at each feeding should vary from 9 to 12 ounces. Bread-crumbs, zwieback or breakfast biscuit may be given with the 7 A. M. and 5.30 P. M. feedings. Orange-juice, one to two ounces, diluted with equal parts of water, may be given between feedings for its laxative action. By the thirteenth or fourteenth month the child should be weaned from the bottle and taught to drink from a cup or spoon.

Beef-broth, chicken-broth, or lamb-broth may be given about the fourteenth or fifteenth month, and at the sixteenth month rice, potato, macaroni, butter, and soft-boiled eggs may be gradually added to the diet. The broths are to be made of such consistence that they turn into a jelly when cool. They may then be diluted with equal parts of hot water before using. The fat should be skimmed off in the making while hot. The cereals may be made as for older children, and should be cooked for at least two hours. From the fifteenth to the eighteenth month, therefore, the scheme of feeding may be outlined as follows:

7 A. M. : Plain milk, bread and butter, and either a cereal or soft-boiled egg.
10.30 " " : Plain milk, bread and butter.
1.30 P. M. : Bowl of broth, 4 to 8 ounces, or 1 to 3 ounces of beef-juice, with boiled rice, baked potato, or macaroni, and bread and butter, baked apple, or prune-juice.
5.30 " " : Plain milk with bread and butter.
9 " " : Plain milk.

The quantity of milk consumed at this age should be about one quart. Water should be given between meals, twice a day. The child's appetite should be satisfied at each feeding, but it should not be satiated. The 9 P. M. feeding can now be omitted if the infant will sleep through the night without waking.

At the eighteenth month the feedings should be four a day, and the general character of the food allowed is seen in the following list:

Milk	Plain crackers	Asparagus tips
Mutton-broth	Barley-jelly	Stewed carrots
Chicken-broth	Oatmeal-jelly	Mashed cauliflower
Beef-broth	Pettijohn	String-beans
Beef-juice	Cream of wheat	Butter
Soft-boiled eggs	Wheat germ	Cream
Scrambled eggs	Farina	Peas
Dropped eggs	Rice	Orange-juice
State bread	Hominy	Baked apples
Toasted bread	Tapioca	Apple-sauce
Zwieback	Baked potato	Stewed prunes
Breakfast biscuit	Mashed potato	Junket
Milk-toast	Plain macaroni	Custard
	Spinach	Corn-starch

Meats are not necessary or desirable until the end of the second year. They should then be given in the form of scraped rare

beef in amounts of one to two ounces. After the second year three meals a day are sufficient.

The difficult cases of feeding which are suffering from indiscreet feeding in the first year cannot at once be started on the schedule outlined. It is wiser to begin with very weak modifications of cow's milk, such as would be appropriate for a child of five or six months, while the quantity and intervals are made to correspond as closely as possible with those of a healthy infant of the same age. Starting with such a foundation, the strength and character of the food are changed along the lines indicated, in strict accordance with the state of the child's digestion and nutrition. Close observation of its condition and keen judgment as to its individual requirements are no less important at this period than in the first twelve months of life.

DIET DURING ILLNESS

In almost all acute infectious diseases the diet should be reduced to the simplest foods during the febrile stage. Bottle-fed babies should be given formulæ of from one-half to three-fourths of the regular strength, and boiled water be given freely between feedings. Infants in the second year and older children should be kept upon whole milk diluted with barley-water or partially peptonized, broths, beef-juice, junket, and thin cereals.

Forced feeding not infrequently must be resorted to when the swallowing reflex is lost or when the daily quantity is greatly reduced, owing to aversion to food. This can best be accomplished by gavage or nasal feeding, either of which can be easily administered in babies under two years and in all children who are comatose or semi-comatose. Older children often resist the passage of a tube, and are so greatly frightened by its use that the method becomes impracticable. In such cases one must resort to rectal alimentation. Skimmed milk peptonized for an hour is the best basis for nutrient enemata. The whites of one or two eggs may be combined with the peptonized milk. The amounts to be given under one year range from two to four ounces. It is seldom wise at any age to give more than six ounces, as large quantities are quickly expelled. The nutrient should be given high, the rectal tube being passed at least eight or nine inches, so that the food may be deposited in the sigmoid. The lower bowel should be cleansed once a day with weak salt solution, and after the washing as much of the saline should be injected as can be retained. The enemata should not be repeated oftener than once in four or six hours, as they are a decided irritant to the rectum.

Nine-tenths of our success in the management of acute illnesses depends upon our ingenuity in applying the resources of infant-feeding. The tastes and whims of the child must be considered, but great firmness and tact are necessary. An experienced and intelligent nurse will often succeed in persuading a child to take its prescribed rations, when the efforts of the mother or nursery-maid result in complete failure.

THE GENERAL PRINCIPLES OF DRUG TREATMENT

By Sir Lauder Brunton, Bart., M.D., D.Sc., LL.D., F.R.C.P., F.R.S.

There is no department of human activity that has been more influenced by fancy than the treatment of disease, for treatment depends upon the ideas held regarding the cause of disease, the nature of its effect upon the patient, and the mode of action of the remedies employed. If we try to classify these attempts, we shall find that they fall into two groups—those of facts and those of fancy. The human mind in its search after healing seems to have oscillated, like a pendulum, between these groups, sometimes inclining to fact and sometimes to fancy, until it seems now to be settling down to a position intermediate between the two—connecting and coördinating facts by means of ideas, while it corrects its ideas by experiment and observation, so as to make them accord with facts.

In another work* I have discussed fully the various systems of healing which have prevailed, so that I need not go at length into them here, but may refer those who are interested in them to it. We may briefly classify them under five headings:

(1) Instinctive; (2) supernatural; (3) empirical; (4) theoretic; and (5) rational.

Instinctive Method.—Modern investigation is constantly tending to limit the range of instinct, and to attribute to education and experience many actions formerly supposed to be instinctive: yet it is convenient to retain the term for such actions as "eating" to allay hunger, and "drinking" to quench thirst. Cravings similar to those for food and drink in general sometimes occur for particular articles, in lower animals or in man, and lead dogs to eat grass, or lead buffaloes to rush for hundreds of miles over the prairies to the salt licks. Such cravings occurring in patients frequently point in the right direction for treatment; they should not be hastily overlooked, or their gratification systematically refused, by the medical man or attendants, as was too often the case. Thus, the thirst which indicates to a healthy man the necessity of drinking should not be refused gratification merely because a patient is feverish. At the same time these cravings require to be interpreted with judgment. Thus, the cravings of a convalescent patient for salt fish or ham may simply indicate the need for salt to assist in the restoration of his wasted tissues. Salt, given either with food or as a medicine, would be beneficial, but the article desired would probably be harmful from its

* Goulstonian Lectures on Pharmacology and Therapeutics, 1880, London, Macmillan & Co.

hardness and indigestibility. In like manner other cravings, such as a desire to eat earth, should induce us to consider the advisability of giving lime-salts or some other inorganic constituent of the body.

Supernatural Method.—According to this method, diseases were supposed to be due to the direct agency of evil spirits, or to be the messengers of vengeance of a deity, and the method of cure, consequently, consisted in attempts to frighten or bribe the supernatural being who had caused the disease. This method is still in full operation in some parts of Africa, where the native offers gifts to his idol or fetish, and if his offerings do not bring a cure, he beats or burns the idol or fetish. Traces of it still exist among ourselves, for the sign ℞, which usually heads our prescriptions, and is often supposed to be simply a contraction for "recipe," is really an invocation to Jupiter, ♀ being the sign of this planet.

Empirical Method.—While the supernatural method just mentioned deals exclusively with fancies, the empirical method restricts itself to facts. By it, drugs or other methods of cure are tried haphazard, or with little knowledge of their action, and, being found successful in some cases, are again administered in others which seem to be similar. The most extensive collection of empirical observations ever made was that collected by the Æsculapians at Cos, and transmitted to us by Hippocrates. We still are forced in many cases to employ the empirical method. The disadvantage is that if it fails in any particular case, we are left in ignorance of what to do.

Theoretical Method.—The human mind appears to be unable to content itself with a mere accumulation of facts, and tries to coördinate them by some hypothesis or other. In the theoretic methods, of which there were many, facts were entirely or almost entirely thrown aside, and pure fancies took their place, just as much as in the supernatural method. Traces of those fancies still remain to the present day in the terms "astringents" and "laxatives," or the popular phrase, "opening the pores," all of which express not facts, but the fancies of Asclepiades and Themison in the first century B. C.

Rational Method.—The essential difference between this method and those preceding it is that in it we have neither bare facts nor pure theories, but facts coördinated by theory, and theory corrected by facts. Rational medicine is a very complex subject, and stands on the border-line between science and art. In practice it is, to a great extent, an art, and successful treatment depends, to a great extent, on the power of the practitioner to apply scientific or empirical knowledge to each individual case, just as the success of an artist depends upon his individual power of drawing correctly and coloring rightly, although he may be guided and aided by scientific knowledge of perspective and color combination.

The complexity of rational medicine is due to its requiring a knowledge of so many different things. It requires, first of all, that the practitioner shall be able to diagnose correctly the kind of disease

from which the patient is suffering by the symptoms he presents, because a mistake in diagnosis may lead to wrong treatment. It requires a knowledge of the vital processes which occur in the body of the patient during the course of the disease,—that is, its pathology,—which in its turn requires a knowledge of the vital processes in the healthy body,—that is, physiology,—and a knowledge of the cause of the disturbance, or etiology. Besides all these, is required a knowledge of chemistry, which includes the composition of the cells in different parts of the body, of their mode of growth, of the ferments or other substances which they produce and excrete, of the poisons they form, and the interaction between cell-bodies and the ferments, toxins, etc., of microbes attacking the various organs of the body, and not of this only, but also the effect of those of different parts of the body upon each other.

It has been very truly said that some physicians study the disease, others treat the disease, and yet others treat the patient. If our knowledge of the disease is imperfect, it is perhaps best to treat the patient, and to make sure that if we do no good we, at any rate, do no harm. Many diseases run a definite course, and if the patient is not interfered with, the vital equilibrium tends to become restored without any medication, whether it has been disturbed by microbes from without or alterations from within. This natural tendency to recovery has formed the basis of many systems of quackery—from the sympathetic salves which were daily applied to a weapon, while the wound that it had inflicted healed peacefully under undisturbed bandages, to the homeopathic globules of carbo ligni and other inert remedies, faith cures, and pilgrimages to holy shrines. In the latter case, however, another important element comes in besides that of non-interference, for faith is a very important factor in cure, and the influence of the mind upon the body is very great. Perhaps no better illustration of this can be given than the extraordinary purgative effects that have been frequently observed after the administration of a bread pill, coupled with the strong assurance that it would certainly act. That operations have been performed in the so-called hypnotic condition without any pain being felt by the patient is also, I think, beyond dispute. The personal element on the part of the physician has a great deal to do with the success of his treatment, and sometimes men who are full of knowledge, but lack confidence in themselves, are really much less successful in curing their patients than others who are in comparison grossly ignorant, but full of confidence which they impart to their patients.

RELATION OF DRUGS TO THE CELLS OF THE ORGANISM AND TO DISEASE GERMS

But while the effect of faith is very great in influencing the action of drugs and of other means of cure, yet drugs themselves, when properly used, have an enormous power to cure and to prevent disease. In order to understand their action in preventing, controlling, or

curing disease, it is necessary to bear in mind that the cell is the unit of life, and the pharmacology of the future will consist in a precise knowledge of the action of drugs upon cell life. All organisms, however great or however small, however simple or however complicated, consist of cells; sometimes these are isolated, sometimes built together, sometimes simple, sometimes highly differentiated. These cells may be floating in a nutrient medium outside the body, as, for instance, bacilli and cocci, or inside the body, as leukocytes or erythrocytes, or they may be built up into connective tissue, glands, muscle, or nerve—but all cells have four functions:

They all: (1) Digest and absorb; (2) absorb and digest or transform; (3) respire; and (4) secrete.

I have mentioned here digestion and absorption twice, but in different order, because digestion is not only necessary to prepare many bodies for absorption, but, after absorption into the cells, a second digestion or transformation takes place. To take a common instance: the yeast plant, when sown in a solution of cane-sugar, excretes a ferment which splits up the cane-sugar and forms glucose, which is then ready for absorption. After the glucose has been absorbed into the cell, it is again digested and transformed so as to produce alcohol and carbonic acid. For a long time this process was looked upon as due to "vital action," but we now know that the formation of alcohol, like the conversion of cane-sugar into glucose, is effected by a ferment or enzyme which will continue to act after the cell which produced it is dead, just as the pepsin of commerce will continue to digest meat long after the pig which furnished it has been slaughtered. But the enzyme which digests cane-sugar is excreted from the cell during its life, while the enzyme which converts glucose into alcohol is retained within the cell, and is given out only after the cell has been broken up, as, for example, when it is pulverized along with some hard powder. We have thus to consider in the case of all cells—(1) Extracellular digestion, and (2) intracellular digestion, or tissue metabolism, both of which can be modified by drugs.

We usually speak of animals as living in air, but Claude Bernard clearly pointed out that the cells of which our bodies are composed do not live in air, but in a fluid medium—the lymph which bathes them. It is from this lymph that they obtain oxygen for their respiration, as well as their nutriment, and it is to it that they return the products of their respiration and of their secretion. As Ehrlich has shown, in each cell there are three zones. In the outer one there is more or less complete oxidation; in the inner one there is little oxidation and more or less complete reduction; and in the intermediate one, oxidation and reduction alternately gain the upper hand. As one can readily suppose, the products of cell life vary according to the amount of oxygen at their disposal, and also according to the ferments which they are able to produce. We find that when unicellular organisms, such as bacteria, are grown with an imperfect supply of oxygen, they are apt to decompose the medium in which they live in

such a way as to gain from it atoms of oxygen to supply their needs at the cost of a wholesale destruction of the nutrient media.

The cells excrete ferments which may be useful to them in the processes of digestion or respiration. They also excrete certain products, some of which are useful to themselves; others, especially in large quantity, may prove toxic. Thus, certain cells appear to give out substances likely to attract to them other cells which may serve them as food, but in large quantities the accumulation of the waste-products tends to destroy the cells themselves, although these very waste-products may be useful to others.

All cells, then, tend to alter the medium in which they live by digestion, by respiration, and by excretion, and the alterations thus produced, while they prove injurious or fatal to the first class of cells, favor the growth of another class. Thus, alcohol when accumulated beyond a certain extent in a liquid checks the growth of the yeast which produces it, but forms a suitable soil for the vinegar-plant; and the vinegar thus produced checks the growth of Mycoderma aceti and affords a favorable soil to the mucous fungus. Cells grown together in the same medium may aid one another's growth or may oppose it. The effect of the reaction of the liquid upon the growth of cells is very great: while some thrive well in a strongly acid medium, others do much better when it is only faintly acid or alkaline.

The action of ferments depends very greatly upon the reaction of the medium on which they are acting. For example, pepsin acts in an acid solution and ptyalin or trypsin in alkaline or very faintly acid solutions. We are gradually coming to recognize that the whole of tissue change in the body is affected by ferments, either free from cells or contained in cells. Each of these ferments has probably an optimum of alkalinity or acidity for its action, and this reaction is probably in many cases determined by the products of the previous action of some other ferments. It is no wonder that we find that acids and alkalis are among the most favorite prescriptions of the physician, and that alkaline waters have, all through the history of the world, drawn crowds of sick people to drink at their source in order to recover from their diseases. But all alkalis are not alike. Potassium, sodium, calcium, lithium, magnesium, etc., have all their own position in the body, and an excess of one deranges the balance of nutrition. It is for this reason that the buffaloes, to which I have already referred, are driven by an irresistible instinct to rush to the Salt Lakes. The herbage on which they feed contains an excess of potassium, and in order to lessen the excess in their own bodies, they greedily take the sodium chlorid which is to restore the balance again. It would appear that we are able, to a certain extent, to replace one alkali by another, or even by an alkaline earth, but the tissue in which this replacement has occurred becomes altered in its physical course. Thus, strontium, calcium, and barium render the contraction of muscle slower and longer, while potassium counteracts this effect and makes it shorter and quicker. It is probably on this account that hard waters, acting on the invol-

untary muscular fiber of the intestine, produce constipation, while potassium salts will sometimes remove its effects. But it is not only the bases which modify the tissue change: acids do so also, and the chlorids, sulphates, and phosphates have their own place in the economy, and by modifications in their amount, tissue change may be altered; but the precise effects of these, however, are still to be ascertained. We do not yet know how far nitrogen may be replaced by allied bodies, such as arsenic and phosphorus, or whether these act in some other way than that of replacement; but all of them have a marked effect upon tissue change, benefiting them, as a rule, when in small doses, and proving most injurious when excessive.

The effect of temperature is no less marked than that of reaction, because low temperatures do not destroy cell life, but they check its manifestation. High temperatures destroy all life completely, while for each cell there seems to be an optimum temperature in which it thrives best. When this temperature is modified, either upward or downward, the vital activity of the cell is lessened.

The composition of the media exercises great influence upon cell life and upon the products that the cells form. My friend, Dr. Croft Hill, has shown that ferments may have a double action, and that a ferment which tends to produce maltose from glucose, when the former is comparatively small in amount, may reverse its action and transform maltose into glucose when the proportion of the latter is small. All the functions of the cell can be modified by drugs which may lessen the digestive, the respiratory, or the excreting powers of the cell, and may modify or antagonize the injurious or lethal power of the ferments or toxins they produce. In polycellular organisms the same functions are possessed by the cells which compose them; but we have superadded the effect of circulation and of the dependency of one group of cells upon others. To make this clear I often refer to the diagram of a sponge made by the late Professor Huxley; from this it is readily seen that the vital processes of one group of cells will alter that of others which depend upon it. It also shows that a drug which would have but a slight effect upon monocellular organisms may prove fatal to a polycellular organism, because it acts upon some delicate part in a particular group of cells. Thus, in a sponge the life of the organism may be destroyed by a drug which may act upon the cilia alone, because in this way the circulation is arrested and the cells depending upon it die, although the drug would have had little effect upon them directly. In the life of all organisms there is a struggle for existence and there is a constant attack and constant defense. The first means of defense is to flee from the invader, and sometimes the leukocytes may be observed to avoid an intruding cell, much as a group of men might leave a grizzly bear or tiger severely alone. Another means is to resist the invaders by opposing a hard epidermis which it cannot penetrate, as in the skin, or to remove them, as is done in the nose and respiratory mucous membranes by cilia, in the lungs and respiratory passages by coughing,

in the stomach by vomiting, in the intestines by diarrhea. When the invaders have passed the first lines of defense and have attacked the cells of the tissues, they may be resisted by secretions which are poisonous to them or by the cells actually engulfing and digesting them. Nearly all drugs that prove fatal to the unicellular organisms which produce sepsis or disease are also injurious to the cells of living bodies. Outside of the body they can be used in any quantity so as to destroy completely disease germs, and antiseptics are now constantly employed for this purpose. Nature's antiseptics are oxygen and light. It is true now, as it was of old, that "the pestilence walketh in darkness,"* and free exposure to light and air tends to destroy disease germs.

ANTISEPTIC TREATMENT

The antiseptics which are most commonly used outside the body are carbolic acid; coal-tar products of various sorts and chlorinated lime, for the disinfection of privies; formalin in vapor or fumigation with sulphur for the disinfection of rooms; heat, and especially moist heat, for the disinfection of clothing and instruments; and carbolic acid, creosol, and metallic salts, such as perchlorid and periodid of mercury or formalin, for the disinfection of surgical instruments or the hands of the operator.

Drugs on the Skin.—In sterilizing the skin it is always to be remembered that watery solutions of antiseptics will do nothing against microbes that are protected by fat; fatty matter, therefore, must be removed by thorough washing with soap, or by washing with ether, either pure or containing an antiseptic, like perchlorid of mercury, which is soluble in it. The same rule is to be borne in mind in the treatment of skin diseases depending upon parasitic fungi, and perhaps the treatment of such diseases would be less prolonged and more satisfactory if the operators were to bear in mind that a fluid is best sterilized by intermittent boiling, and that the frost which kills the blossoms in our orchards is the one which comes after a period of warmth. Intermittent poulticing, to soften the parasites, alternating with the application of parasiticides, may prove more efficient than a continued application of antiseptics.

Where the parasite has penetrated into the hair-follicles, the hairs must be removed, since otherwise the antiseptic cannot reach the fungus. In ring-worm, a 1 per cent. solution of salicylic acid in chloroform or ether both clears away the fat and acts as an antiseptic. In the first stage this alone may be successful, but later on, when the disease has a firmer hold, chrysarobin ointment, 1 : 50, sulphur ointment, 1 : 8, alone or with carbolic acid, 1 : 16, and perchlorid of mercury, 0.5 to 2 per cent., dissolved in alcohol or ether, and oleate of mercury in oil or ether or with lanolin, are all useful. Copper, formalin, tar, thymol, and hyposulphite have all been employed, and iodin in the form of tincture or liniment is not infrequently very ser-

*Psalm xci, 6.

viceable. All such applications, however, are being superseded by the *x*-rays, which effect a more rapid cure. In favus the thick crusts must be removed, and parasiticides, such as have already been described, must be rubbed in. Warmth applied over sublimate compresses has proved useful, probably in the way just mentioned, of tempting the fungus to grow by the warmth and moisture, and then destroying it by the antiseptic. Animal parasites are, as a rule, best treated by sulphur ointment or white precipitate ointment.

Drugs on Mucous Membranes.—In considering the application of antiseptics to mucous membranes we have to take into account the effect of the drug upon the microbes and upon the mucous membrane. If the mucous membrane is soft, the microbes may enter into it a certain distance, and thus be protected from the action of an antiseptic; we, therefore, frequently have to employ at the same time antiseptics and astringents. The microbes themselves frequently set up a condition of congestion in the mucous membrane, with increased secretion and nervous irritation, evidenced by discomfort, pain, or increased movement in hollow muscular organs, such as the stomach, intestine, or bladder; in addition to antiseptics and astringents, therefore, we often have to employ nerve-sedatives.

TREATMENT OF THE RESPIRATORY SYSTEM

The respiratory passages are especially liable to constant attacks of microbes, which are inhaled with the inspired air. These are, to a certain extent, prevented from passing down by the mucus which lines the passages, and to which they adhere, and also by the cilia with which the mucous membrane of the nose and upper part of the respiratory passages is furnished. Irritating substances give rise to reflex efforts for their ejection in the form of sneezing, hawking, or coughing, according as the irritation affects the nose, pharynx, trachea, bronchi, or lungs. All these reflexes are calculated to clear the respiratory passages, but sometimes, after the irritant has been removed, the mucous membrane remains irritated and expulsive efforts are made, which are no longer useful, but only injurious. This is also the case when the irritation depends upon inflammation of the pleura or of the lung itself, and even when, as in pulmonary tuberculosis, a certain amount of expectoration is necessary, the coughing may be altogether out of proportion to the desired effects and may simply tend to exhaust the patient. The nasal mucous membrane is benefited by a mixture of astringents and antiseptics, but these must be diluted so as to prevent them from irritating the mucous membrane, and should be used with due precaution to prevent their entrance into the Eustachian tubes. Consequently, when they are applied by a nasal douche, the pressure under which the application is made should be very low indeed, and sniffing is, as a rule, inadvisable, for the same reason. As pure water is a powerful irritant, the solutions should be made with normal saline solution—0.6 per cent. of NaCl.

In order to reach the posterior nares, the larynx, and the bronchi,

they may be employed in the form of a spray. For this purpose menthol, thymol, eucalyptus oil, creosote, carbolic acid, iodin, etc., either in weak saline solution or dissolved in oily media, are useful. Sometimes also actual laryngeal injections are employed. To relieve the sneezing, as in hay-fever, weak solutions of cocain—0.5 per cent.—are frequently used. They have the disadvantage of sometimes leading to the cocain habit; and the use of solutions of morphin or opium for a similar purpose may also lead to a habit. Many violent coughs, especially those which occur in the morning on rising, depend upon postnasal catarrh, and unless this be treated by local astringents, such as the application of iodin or tannin to the posterior nares, all cough mixtures prove useless.

Other coughs of particularly violent and explosive character are due to irritation of the larynx or of the bifurcation of the bronchi by chronic inflammation, and when these also fail to yield to ordinary cough mixtures, they may be quieted by cocain spray or by insufflation. The persistent cough of laryngeal phthisis is very often relieved better by insufflation than by anything else—a good formula for which is $\frac{1}{2}$ grain of starch with $\frac{1}{16}$ to $\frac{1}{2}$ grain of morphin. When the inflammation is at all acute, confinement to the room or even to bed, with a "bronchitis kettle" discharging vapor into the room or into a tent upon the bed itself, is required; a warm poultice or wet compress around the neck is also useful. Inhalation of steam lessens the irritation in the throat, and compound tincture of benzoin or oil of pine may be added to the water. In acute bronchitis, when the mucous membrane is congested, with little or no secretion, relief is best given by free purgation and the use of ipecacuanha, antimony, or pilocarpin, until the secretion becomes free, after which ammonium chlorid and the terebinthinates, with nerve-sedatives, such as codein or heroin, to lessen the cough, are useful.

In chronic bronchitis, lasting for years, both patient and doctor are apt to become tired of medication. In the out-patient department of St. Bartholomew's Hospital, where, during more than seven years, I saw as many patients as from 500 to 700 in a week, many of whom, of course, suffered from chronic bronchitis, I tried expectorants and remedies of all kinds. The three remedies which the patients selected for themselves as doing them most good were cod-liver oil, turpentine liniment to the chest, and an ipecacuanha and squill pill at night or night and morning to relieve the cough. This pill, in addition to ipecacuanha, squill, and ammoniacum, contains about $\frac{1}{4}$ grain of opium in each 5-grain pill, and either one or two of these pills at night was the common dose. In cases of bronchitis, where the expectoration is very profuse and the patient weak, care is required not to give an overdose of narcotic or sedative, lest during the sleep which it produces the mucus should accumulate in the respiratory passages to such an extent that the patient on awaking is unable to expectorate it and is suffocated by it. In phthisis we have to use medicines to relieve the irritating cough, so as to prevent exhaustion and to secure

better sleep, but at the same time we have to guard against lessening the appetite and interfering with the digestion, as this would lower the vitality of the patient and ultimately do harm, rather than good. Small doses of opium, codein, or heroin, combined with hydrocyanic acid and nitric acid, especially when given just after a meal or at bedtime, often help considerably, more especially as in many patients an accession of coughing appears to take place from the ingestion of food. With these, small doses of digitalis, such as two or three minims of the tincture, may be usefully combined. In bronchiectasis, when the sputum comes up in very large quantities and has a most disagreeable odor, musk covers the smell and also helps the patient. Musk is, indeed, a useful respiratory stimulant, and in cases of pneumonia, when the respiration appears to be failing, the tincture of musk—although the remedy is now almost looked upon as obsolete—is, I believe, really very useful, in doses of 1 dram or more every two hours.

In pneumonia it is doubtful whether any drugs will either alter or quicken the inflammatory process in the lung. Ammonium chlorid in 10-grain doses every two hours has been used for this purpose, but, as a rule, the object the physician has in view is to keep the patient alive until the pneumonia shall run its course. For this purpose careful feeding and nursing are even more important than drugs. If there be much pain present, as is frequently the case when pleurisy is associated with pneumonia, nothing gives such instant relief as half a dozen to a dozen leeches over the place, but where the cough is severe and ceaseless, opium or Dover's powder may be given to ease it, with bromids if the patient is restless. Antipyretics are, as a rule, rather injurious than beneficial, but if the temperature tends to rise high, sponging and cradling may be employed with advantage.

Sometimes, when one lung is clearing up and the second is becoming affected, it is simply a race for life to keep the patient alive until the first lung shall have cleared sufficiently before the second becomes useless. In such cases the use of oxygen may make all the difference. In ordinary cases, when the respiratory space is much diminished, the intermittent inhalation of oxygen for ten minutes at a time every hour is of advantage, and it is to be borne in mind, as Sir Douglas Powell has said, that the first organ to benefit by well-oxygenated blood is the heart. When the respiratory space is very limited, and when there is, as I have just said, a race for life, the oxygen should be given continuously, allowing a funnel connected with the oxygen holder to hang over the patient's face, so that the gas shall stream regularly into the nose and mouth. Another drug which sometimes turns the scale between life and death is strychnin injected subcutaneously, $\frac{1}{20}$ or even $\frac{1}{10}$ grain being given for a dose. When the heart is laboring and the venous system is congested, removal of 10 or 15 ounces of blood from the arm relieves the heart's action and may save the patient. When the temperature is very high and the delirium acute, a wet-pack or cold affusion is of the utmost service.

Ice-bags have been strongly recommended, but their use has not become general. If the heart threatens to fail, 5 grains of calcium chloride every two to four hours may be useful, and grape-sugar, either by enema or intravenous injection, has a stimulating action on the heart.

TREATMENT OF THE DIGESTIVE SYSTEM

Treatment of the Mouth.—In the mouth, the teeth, tonsils, and pharynx are all liable to invasion by parasites, and here the strength of the parasiticide is limited by its irritating power over the tissues in the buccal cavity. In cleaning the teeth, too much attention is usually bestowed upon the use of a tooth-brush and too little upon cleaning the interstices between the teeth, where food and bacteria accumulate and are not removed by the tooth-brush. A tooth-pick of soft wood is one of the best means of removing them, and it should be used at night, because it is during the hours of sleep, when the tongue is quite at rest, that the most favorable time is afforded for the growth of septic organisms. For this reason, if milk is drunk at bedtime, either by children or adults, the mouth should be carefully rinsed with water afterward.

The crypts of the tonsils appear to form a refuge for micro-organisms, and enlarged and inflamed tonsils are frequently much benefited by mixed astringents and antiseptics, such as a mixture of equal parts of tincture of iodin and glycerite of tannic acid.

Among the conditions in the mouth which give rise to great discomfort on the part of the patient are excessive dryness or excessive salivation. Great dryness is frequently due to obstruction of the nasal cavity by thickened mucous membrane, by polypi, or by adenoids. The consequence is that all the air passes through the mouth, which is held open, and the tongue thus becomes uncomfortably dry. This is most marked in the morning, when the patient awakes after sleep, and if anything which will cause a thick fur, such as a draft of milk, has been taken shortly before going to sleep, the tongue may be covered with a thick brown or even black coat, which greatly alarms the patient. The remedy for this is, of course, attention to the nose, rather than to the mouth. Another cause, however, is lessened secretion of the salivary glands, and this occurs to a great extent in febrile conditions, though it is also a frequent consequence of nervous conditions. A good example of this is the Indian way of detecting thieves by making them chew rice and then spit it out, when the culprit generally puts his rice out dry, and the innocent one moist, fear of detection having dried up the guilty one's salivary secretion. In a lesser degree this occurs with nervousness and worry, in which cases the saliva is often found to be frothy. For such conditions the treatment must be directed to the nerve-centers, bromids and valerian being given to quiet them, and the cause of worry should, as far as possible, be removed or kept out of sight. The salivary glands may be stimulated by weak acids, such as lime-juice or potassium bitartrate,

and these may be used to wash out the mouth or taken in sips, so as to moisten the pharynx and allay thirst. A combination of these with some demulcent substance, such as glycerin, assists their action, lessening subsequent evaporation from the interior of the buccal cavity.

Thirst is frequently dependent quite as much on the dry condition of a mouth and pharynx as upon absolute want of water in the body, and may be relieved by gargling the throat and washing the mouth out with water, either very cold or very hot, with the addition of lime-juice or of some mucilaginous substance, such as oatmeal. It is especially the sides of the pharynx that require to be attended to, and a little liquid well applied to the pharynx sometimes relieves thirst more than large drafts quickly taken, which pass down the center of the gullet and appear to leave the sides of the pharynx comparatively dry. Other substances which tend to stimulate the salivary secretion are potassium iodid and potassium chlorate. Both appear to be excreted in the salivary glands, and to increase the quantity of fluid poured out by the glands. Large doses have rather a contrary action.

Excessive salivation is sometimes reflex from irritation of the teeth, gums, or tongue. Where the teeth are defective, they should be stopped (filled) or removed. Inflammation of the gums may be checked by tincture of iodin penciled round the roots of the teeth, and superficial glossitis may be kept in check, if not cured, by the application of strong solutions of chromium trioxid or of cyanid of mercury, 15 grains to the ounce, and the frequent use of boric acid, potassium chlorate, and other antiseptics, either as a mouth-wash or as soft pastilles, made up with gelatin, which can be kept a long time in the mouth and the local action of the drugs from the tongue thus thoroughly assured.

The treatment of toothache will be considered under the head of pain, but caries may be dependent not only upon local acidity in the mouth, but upon general conditions of the system. I have succeeded in arresting it by the administration of lime salts during pregnancy and lactation, where the teeth of the mother appeared to be suffering from the drain of lime salts from her system to supply the needs of her offspring.

Treatment of the Gullet.—It is difficult to apply drugs to the gullet on account of the rapidity with which they pass down, but sometimes, in cases of painful swallowing, bismuth carbonate with enough gelatin, glycerin, and rose-water to make it into a thick paste may be tried, as it tends to smear the surface of the esophagus on its way down.

Treatment of the Stomach.—Antiseptics are much used in the stomach, in order to prevent decomposition of food, with formation of acid or evolution of gas. If given some time after food, when organisms are in full growth, their power of checking fermentation is, of course, at its minimum. They are best given either before food, on an empty stomach, or else with, or immediately after, meals. When the stomach is much dilated, it is, of course, almost useless to put

small quantities of an antiseptic into a large fermenting mass, and the stomach should, therefore, be washed out beforehand. This is most easily done by the stomach-tube, but in the case of nervous and highly sensitive people, who object to the use of the tube, a somewhat similar result may be obtained by making them drink several tumblerfuls of hot water and tickling the fauces with a feather so as to cause vomiting. This is repeated several times, by which means the stomach can be cleaned.

In the stomach, as in the mouth, we have increased and diminished secretion and sensitiveness, and we have, in addition, to consider increased or diminished motor power. Diminished sensibility may show itself as lack of appetite, and in such cases the appetite may be restored by drugs, such as nux vomica or strychnin, which increase the sensibility of the nerves, or by substances, such as bitters and alcohol, which have a local stimulating or irritating effect upon the sensory nerves of the stomach, and which in large doses will produce vomiting. But the researches of Beaumont have shown that appetite may coincide with two conditions—(1) lack of sensibility in the stomach, and (2) excessive irritation in the stomach. In the first case, a slight irritant, such as a bitter or even food, will bring on an appetite, but in the second case, such drugs will rather lessen the appetite and bring on vomiting. Therefore, when the lack of appetite depends upon excessive irritation of the stomach, it must be treated by sedatives, such as bismuth and opium, or other medicines having a similar action.

Secretion from all the digestive glands has been shown by Pavloff to depend very much upon the reflex stimulus afforded by tasty and palatable food, and for this reason a large and varied meal, even with a good deal of wine, if well cooked and taken in agreeable company, may be digested quite easily and satisfactorily, when a plain meal, poorly cooked, and without pleasant surroundings, may cause indigestion and discomfort. Probably it is for this reason that all nations have found the use of condiments an advantage, and although *per se* they may not help digestion, but rather interfere with it, they may, by the agreeable stimulation they give to the nerves of taste, greatly increase the flow of digestive juices, not only in the stomach, but in the intestine and the pancreas. As most condiments, however, have a somewhat irritating action, they require to be used in moderation, lest they irritate the gastric mucous membrane and bring on a catarrhal condition. More especially is this the case with alcoholic drinks, which, although they may stimulate the digestive secretions in the way already mentioned, tend, in themselves, rather to interfere with the action of the digestive ferments which have been already secreted.

The reaction of the chief digestive juices is alternately alkaline and acid, that of the gastric juice being acid, while the saliva and the secretion of the intestine, as well as of the liver and pancreas, which pour their secretions into it, are alkaline. Alkalis seem to stimulate the secretion of acid juice, and acids that of alkaline juices. Careful and prolonged mastication, which leads to abundant secretion of

saliva, therefore, tends to increase the secretion of gastric juice, and the acid gastric juice in its turn stimulates the secretion of the alkaline juices of the glands connected with the intestine. At the same time acids appear to check the formation of acid secretions, and alkalis of alkaline secretions. As many people are in the habit of bolting their food, and the stomach, therefore, lacks the natural stimulus which would be afforded by alkaline saliva, one of the most common remedies in cases of dyspepsia is a small dose of sodium bicarbonate before meals, which stimulates secretion, and thus not only promotes digestion, but tends to prevent the decomposition of food by extraneous microbes, and, therefore, prevents flatulence. Ten or 15 grains from one-fourth to one-half hour before meals, in combination with some bitter infusion, is one of the most common ways of employing this medicine. Alkalis are also used in much larger quantity, in order to neutralize excessive acidity in the stomach, whether this be due to an unusual proportion of acid in the gastric juice or to acids formed by fermentation.

When any ulceration is present in the stomach, the acid biting on the surface may lead to intense pain and vomiting, and the same is the case with ulcer of the duodenum, in which pain begins just when the acid contents of the stomach are discharged through the pylorus. In both these cases pain may generally be relieved at once by neutralizing the acidity with sodium bicarbonate. This may possibly have a tendency to soften the tissues of the ulcer, and thus to encourage hemorrhage, and it is, therefore, advisable to give, along with it, a small quantity of lime, and in order to neutralize the constipating effect of the lime, a little magnesium may be combined. The proportion I am accustomed to use is about one part of chalk to four or six parts of magnesia, made up to 100 parts with sodium bicarbonate. To this may be added some carminative, such as oil of peppermint, cardamom, or ginger. This may be taken in water, a teaspoonful at a time, until the pain is relieved.

In cases in which the secretion of gastric juice is dependent upon general weakness of the nervous system, nerve-stimulants, such as nux vomica or strychnin, are serviceable, and when, in spite of stimulation, either general or local, the secretion of gastric juice is still insufficient, its place may be supplied by giving pepsin and hydrochloric acid during, or immediately after, each protein meal. In cases of dilatation of the stomach, when it is necessary to wash out the stomach once or twice daily, it is advisable to give pepsin and acid just after each lavage, to replace the natural juices which may have been removed. When the motor power of the stomach is insufficient, and when there is dilatation or proptosis of the organ, good results may be obtained by stimulation with a slightly interrupted electric current, or by the use of high-tension electricity. The latter appears to act as a general tonic, and the stomach tends to resume its normal size. In such cases a belt to support the stomach, by bringing the fundus more on a level with the pylorus, aids the organ to empty itself when the digestion is finished, but in obstinate cases, whether they be due

to atony of the stomach or to actual pyloric obstruction, gastro-enterostomy frequently succeeds when drugs fail.

Treatment of the Intestine.—In the intestine, antiseptics not only lessen the production of substances irritating to the intestine, tending to cause diarrhea and also evolution of intestinal gas, but they tend to remove the condition of autointoxication which frequently occurs from absorption of the products of decomposition. Those most generally employed for the stomach are various aromatic products, such as carbolic acid, or, still better, the sulphocarbolates, creosote, resorcinol, and sulphurous acid. In the intestine the same drugs are employed, and, in addition, we have α- and β-naphthol, salol, naphthalin, and salts of copper and of mercury.

Antiseptics have a much better chance in the intestine, as also in the stomach, if the number of microbes has been reduced by thorough evacuation; and thus in cases of intestinal sepsis it is often well to begin with a good dose of castor oil or by a mercurial pill, followed by a saline, and then afterward to give the antiseptics. In cases in which the sepsis occurs in the lower part of the large intestine the bowel may be washed out by irrigation, and the antiseptics applied in the same manner.

Pavloff has shown that the pancreas is able to adjust the digestive power of its secretion to the kind of food which has been taken. A similar power is possessed by microbes, as Macfadyen and I have demonstrated, so that bacilli secrete proteolytic ferments when they are grown upon a protein soil, and diastatic ferments when grown upon a soil of carbohydrates. They appear, however, to take a longer time than the glands of the human body to adjust themselves to change of pabulum. In consequence of this the microbes in the intestine may be starved out by rapid changes of diet without doing any harm to the organism. For this reason an entirely milk diet is useful in many forms of diarrhea. In others, such as sprue, an entirely meat diet may be even better, and in some varieties of children's diarrhea whey is one of the best nutrients. Starchy foods, such as arrow-root, with little or no protein, are useful in some cases. In the diarrheas of children a change from pure barley water, that is, an entirely farinaceous food, to whey, which is almost a protein food, and back again to barley water, will tend to starve out different classes of microbes and to bring about a condition of health.

When there is nothing of a stimulating character, either mechanical or chemical, in the intestinal contents, the secretion and movements of the intestines will become sluggish and constipation will result. This is a very common ailment in civilized communities, in which all the hard, indigestible part of the food is removed in the process of cooking. Consequently in order to supply a stimulus to the intestine, people frequently take food containing cellulose in a hard and indigestible form, such as bran-bread and whole-meal bread, or fruit and vegetables of various kinds having more or less hard and indigestible skins or fibers. In the case of many foods, the mechanical stimulus afforded by the

skins or fibers is supplemented by the laxative action of the alkaline salts,—citrates, tartrates, or malates,—which they contain, and thus raw apples, oranges, and melons, taken before breakfast, frequently act as efficient laxatives. Figs have also a double action, as the seeds supply a mechanical stimulus, while the pulp is rendered laxative both by salts and by sugar. Stewed figs, roasted apples, stewed prunes, marmalade, treacle, and jams of various sorts all have a laxative action depending on similar properties. Foods, on the contrary, which are readily digested and produce little irritation, either mechanical or chemical, such as milk and farinaceous foods, tend rather to cause constipation; perhaps there is no food so constipating as fine white bread and butter with no vegetables—as the whole is digested and absorbed without leaving any residue. For a similar reason rice, arrow-root, etc., are all looked upon as constipating.

Simple water drunk on an empty stomach the first thing in the morning may act as a laxative; when this is insufficient, salts, especially the sulphates and phosphates of magnesium or sodium dissolved in it, act as efficient purgatives. Salts of this sort cause greatly increased secretion from the intestines, but have comparatively little effect upon their movements, and if the patient remains in the recumbent posture for a length of time after they have been taken, the whole may be reabsorbed, but in the upright position the passage of the liquid through the bowel is aided by gravity and a good evacuation is usually produced.

The muscular movements of the bowels may be stimulated by various substances having a direct action upon them, such as rhubarb, colocynth, jalap, scammony, cascara sagrada, and aloes, and a little nux vomica is often added to increase the sensibility of the bowels to their action. It is probable that they do not all act to the same extent upon different parts of the bowel, aloes especially being supposed to act upon the rectum; in large doses the irritation it produces may be so great as to cause painful hemorrhoids. Instead of giving a single purgative, two or three of different kinds are frequently combined, together with some belladonna or hyoscyamus to lessen griping; this is usually given either at bedtime or just before the last meal of the day. Sometimes, however, a better result may be obtained by dividing the usual dose into three parts, and giving one with each meal.

When the weaker medicines fail to act, recourse is occasionally had to such powerful purgatives as croton oil. One of the best of all is castor oil, especially when there is much secretion of mucus, as in chronic colitis, but its disagreeable taste rather limits its use.

In many persons the rest of the bowel seems to act very well, and constipation is due to inaction of the rectum only. This may frequently be cured by simply evacuating the bowels at a certain time each day, whether there be any desire or not, and if they will not act, 2 drams of glycerin injected into the bowel or a glycerin suppository inserted is frequently sufficient to secure relief. The effect of drugs

may be aided or even rendered unnecessary by a prolonged course of massage to the abdomen, especially if accompanied by the use of faradic electricity.

When expulsion of bile from the body is desired, it is usual to give either a mercurial, such as blue pill or calomel, or vegetable resinous substances, such as podophyllin, iridin, and the like. The power of these to stimulate the bile is very small indeed, and their useful effect is more likely due to an action upon the duodenum, causing them to be passed down the intestine instead of being absorbed. This supposition is rendered all the more probable by the fact that their beneficial action is greatly increased if their administration be followed some hours afterward by a saline. When it is desirable not merely to move the bowels, but to abstract water from the system, as in dropsy, a combination of a saline with a resinous purgative is advantageous; one of the best is compound jalap powder, though elaterin is even more powerful.

Usually active exercise tends to lessen constipation, but there are some people in whom exercise increases it, and their bowels act more regularly when they are absolutely quiet in bed. In such cases the constipation may depend upon reflex inhibition from a floating kidney, tender ovaries, or displaced uterus, and the constipation is better relieved by nerve-sedatives to lessen the reflex, such as belladonna or small doses of opium, than by purgatives. In some obstinate cases, occurring in gouty people, I have found sodium salicylate completely relieve the trouble, and occasionally potassium has a similar action, although sodium has not.

A condition of diarrhea may depend upon diminished absorption, excessive secretion, excessive muscular action, or upon a combination of these factors. One form of diarrhea, characterized by several stools occurring early in the morning, appears to be partly due to diminished absorption, fluids taken overnight acting in the same way as a saline draft in the morning would do in ordinary subjects. This condition may frequently be entirely cured by simply abstaining from liquid in the evening or afterpart of the day. A form of diarrhea due to excessive muscular action is that in which the patient has to pass a motion during or immediately after a meal, the mere ingestion of food into the stomach appearing to stimulate the whole intestine to movement. This is best treated by sedatives, such as bismuth and opium, before meals, but sometimes it yields very readily to minute doses of arsenic given before meals, though whether the arsenic acts as a local sedative in the same way as bismuth or affects the nervous mechanism of the intestine it is impossible to say.

When diarrhea is dependent upon the presence of an irritant, the best plan is to remove the irritant and then apply a sedative. One of the commonest and most successful ways of doing this is by giving a dose of castor oil along with one of opium, and following this by bismuth and chalk along with opium, and, if necessary, vegetable astringents, such as catechu and other forms of tannin to lessen the

congestion and irritability of the inflamed mucous membrane. As diarrhea frequently depends upon the irritant substances produced by bacteria in the intestine, especially in children, frequent changes of diet from protein to carbohydrates, and back again, are very useful, either alone or in combination with antiseptic medication, sedatives, and astringents. One of the most troublesome forms of diarrhea, known as sprue, usually resists all medication, but yields to an absolute milk diet, and sometimes more quickly still to an absolute protein diet consisting of minced beef and hot water. In chronic colitis the best drug is castor oil, but many obstinate cases yield to lavage of the intestine with saline solution. When there is a frequent desire to go to stool, with very little motion, the source of irritation is generally in the rectum or in the sigmoid flexure, and local treatment by suppositories of opium, belladonna, and astringents, or small enemata of a few drams of similar drugs in solution, are more efficacious than drugs administered by the mouth.

Distention, both of the stomach and intestine, by flatulence, is often very troublesome to the patient. In both cases it may depend upon fermentation, and is to be prevented by the administration of antiseptics, as already mentioned. In the intestine certain substances appear to have the power of causing the expulsion of flatus. Among the most important of these are the essential oils and substances containing them: peppermint, cardamom, dill, cloves, caraway, galbanum, and asafetida. Onions and garlic, though rarely employed as medicine, have a similar effect, and all people who are in the habit of living on coarse bread, are accustomed to take with it some of the substances already mentioned.

Treatment of the Liver.—The condition of the stomach and intestines is much affected by that of the liver, for all the blood circulating in them must pass through the liver before it can reach the vena cava.

The resistance to the flow of blood through the portal vein varies very greatly from time to time, as I have found in excised livers. Sometimes the blood will pour readily through, even at a low pressure, while at other times it experiences great resistance. How far this resistance is due to contraction of the vessels themselves, and how far to swelling of the liver-cells, as observed by Professor Sheridan Delépine and myself, has not yet been ascertained. In cases in which the flow is impeded, the venous congestion frequently evidences itself in piles, and it appears to be also the cause of the flatulent distention, of the looseness of the bowels or diarrhea, and of the final ascites which occur in cirrhosis.

Congestion of the liver is considered by some authorities to be merely hypothetic, but any one who has had much to do with patients suffering from malaria knows that the liver will undergo enormous changes in size in a very short time. The modus operandi of mercurials is not made out with certainty, but there can be no doubt whatever as to their effect upon the liver, and in malarial enlargement,

such as I have just referred to, the liver will sometimes regain its normal size with great rapidity after a mercurial purgative followed by a saline. Some cases of diarrhea appear to depend upon venous congestion, especially in men who have been much in the tropics, and sometimes a chronic diarrhea, with enlarged liver, fails to respond to treatment by astringents until the hepatic congestion has been relieved by mercurials and salines.

The functions of the liver are numerous and complicated. It acts as a gate-keeper to the body, arresting poisons on their way from the intestines to the general circulation, returning some to the intestine in the bile, and either destroying entirely or modifying others, so as to convert toxins into antitoxins. It stores up hydrocarbons during digestion in the form of glycogen, and gives them slowly out during fasting, so that it acts as a reserve of force. It also modifies the metabolism of nitrogenous tissues, and during digestion its cells contain a ferment having the power of converting urates into urea, so that its power of preventing any excess of uric acid in the blood is very great. Some of the albuminous bodies midway between albumin and urea, which are formed from protein either during digestion or tissue change, act as powerful poisons if introduced directly into the blood-stream. This is especially true of some of the albumoses, which may greatly alter the coagulability of the blood in either direction, or lower the blood-pressure so much as to arrest circulation entirely. Some of these may change into innocuous bodies during their passage through the intestinal wall; others, again, are probably changed in the liver, and this organ must, therefore, be regarded as one of the most important in the whole body. Those poisons which are simply caught by the liver and returned to the intestine pass out through the bile.

Free bile, such as flows from a biliary fistula, is perfectly tasteless, but bile which is absorbed by the duodenum and excreted by the liver again and again appears at length to become charged with toxic bodies which frequently have a bitter taste, and when the power of the liver to excrete them becomes overtaxed, these toxins enter the general circulation and give rise to drowsiness, irritability, malaise, headache, and other symptoms often classed under the term "biliousness." These frequently culminate in so-called bilious or sick headache, where old bile is evacuated by vomiting and compulsory fasting prevents the formation of much new bile. Immediately after an attack the patients are able to do almost anything without bringing back a headache, but as time passes on and the toxins accumulate, the headache is brought on with greater and greater ease. Both headache and the other symptoms may be sometimes prevented by a mercurial and saline, and a similar result may be occasionally obtained by sodium salicylate and potassium bromid at night.

Sodium salicylate, as was found by the late Professor Rutherford, in a series of experiments upon a case of biliary fistula, may be reckoned as perhaps the most generally useful and powerful of all hepatic stimulants in increasing the secretion of bile. Bile is secreted, as a

rule, under very low pressure, and is forced out of the liver only by the massage which the organ undergoes between the diaphragm, the abdominal walls, the stomach, and intestines. When exercise is small in amount and very gentle, the bile is not squeezed out of the liver, but active exercise, especially when the abdominal muscles are contracted at the same time as the diaphragm, squeezes the bile out and thus tends to prevent biliousness. Many people, especially those who do not feel thirst, take too little water, so that not only their urine, but their bile, becomes thicker than it ought to be. The thick bile flows with greater difficulty through the gall-ducts, and there is a greater tendency to the formation of biliary calculi. Persons liable to such an affection usually benefit greatly by a visit to such a place as Carlsbad, where they drink much water having a slightly laxative action, so that the bowels are kept open, take a plain and limited diet and a great deal of exercise.

The passage of a gall-stone may sometimes be accelerated by giving large drafts of hot water. This makes it not only easier for the patient, but the expulsive movements being performed on a full stomach, greater pressure is produced upon the gall-bladder than if the stomach were empty. At the same time, narcotics and anesthetics not only ease the patient's pain, but tend to relax spasm and allow the calculus to pass. It has been supposed that one or two fluidounces of olive oil every night tends to dissolve gall-stones or to make them pass easily, and concretions have been shown to me as gall-stones after such treatment which were simply masses of fatty acid derived from the oil, and were not gall-stones at all. Nevertheless, I have noticed, as a curious coincidence, that patients taking a wineglassful of olive oil every night have remained for a long time without symptoms of gall-stones. Formerly, I insisted upon a very rigid diet in cases of gall-stones, but the results of this have not been really satisfactory, and I now allow patients to eat as much as they please, but insist upon a large quantity of water between meals.

The circulation in the liver can be modified by the vasomotor center in the medulla oblongata through the nerves which pass down; in the spinal cord, sympathetic cord, and splanchnics, and through these the circulation and functions of the liver can probably be modified. It is supposed that by paralysis of these nerves and dilatation of the vessels diabetes may be produced, but even now the changes in the liver which occur in this disease are imperfectly understood.

Treatment of the Pancreas.—The production of sugar by the liver may be looked upon as an internal secretion, while the bile is its external secretion. The external secretion of the pancreas contains ferments which split up proteins and fats and convert starch into sugar. Its internal secretion, on the other hand, appears to contain a glycolytic ferment which passes by the lymphatics into the circulation, and there tends to aid the combustion of the sugar formed in the intestine by the external secretion.

We know but little as yet regarding the action of drugs in this

disease, those which seem to yield the best results being opium and its alkaloids and alkalis. A combination of sodium salicylate or antipyrin with codein or opium appears sometimes to be better than either alone. Glycerin extracts of pancreas have been used for the purpose of supplying the missing glycolytic ferment, and I have used glycerin extract of raw meat for the same purpose, but without very marked success.

In chronic pancreatitis the stools are frequently very pale and very bulky, the bulkiness being due to imperfect digestion and absorption, and the paleness to the presence of finely divided fat. A few drugs stimulate the pancreas reflexly, such as ether in the stomach, producing secretion. Pilocarpin appears to cause it directly, and potassium iodid to a certain extent does so also in the same way as in the salivary gland. I have on one occasion observed tenderness over the whole of the pancreas, and limited to it, after the administration of potassium iodid, just as one sometimes sees swelling and tenderness of the salivary glands produced by this drug. Our power of stimulating the pancreas is so small at present that in cases of deficient secretion we supplement the lacking ferments by giving them in the form of pancreatic extract—dried pancreatic gland and isolated pancreatic ferments in a more or less pure condition. These are sometimes given before meals, but in laboratory experiments it is found that pepsin and pancreatic ferments tend rather to destroy one another, and it is, therefore, in accordance with our physiologic knowledge to give pancreatic ferments about three hours after meals, when the chyme will be just leaving the stomach to pass into the duodenum.

TREATMENT OF CONDITIONS OF THE BLOOD

There is a great deal of truth in the old saying that the blood is the life, for it is the blood which conveys to the tissues the nutriment and oxygen on which their vitality depends. When the blood-supply is cut off entirely from any part, it dies, and if its blood-supply is diminished, it languishes and becomes feeble. The vitality of all parts of the body, therefore, depends upon the quality and quantity of the blood which they receive. Of late years the composition of the blood has received a great deal of attention, both in regard to its formed elements, its chemical composition, and the ferments it contains. There is still a great deal more to be learned in regard to all these subjects, and at present the chief points we have to consider are deficiency or excess of leukocytes and erythrocytes, deficiency of hemoglobin, and deficient or excessive coagulability.

The most common condition we require to note is that of anemia, or deficiency of the blood as a whole or of certain of its constituents. It may be produced from wounds, childbirth, or profuse hemoptysis and hematemesis; it may occur from continued loss of blood, as in menorrhagia or hemorrhoids, or by long-continued drain of albuminous constituents, as in Bright's disease, chronic suppuration, and pro-

longed lactation; and it may occur also from the destruction of blood by toxic substances. Its treatment will depend, to a certain extent, upon its causation, but in nearly all instances the loss, either of blood as a whole or of its constituents, is accompanied by diminution in the amount of hemoglobin. One of the most important constituents of this is iron, and this metal in various forms is the favorite remedy for anemia. The question of whether inorganic iron is absorbed from the intestine or not has been the subject of much discussion, but there can be no doubt of the increase in the amount of hemoglobin in a very large proportion of anemic patients who are treated by iron, and this, I think, affords such proof as experiments upon the absorption of iron by animals fed with it cannot overthrow.

There can be little doubt that a great deal of the iron usually given in the form of pills or potions is not absorbed, and frequently one notices that a much better result is obtained in anemic patients by sending them to drink natural iron waters than by giving them iron at home. This is, no doubt, due partly to the change, but I believe it is also due to some extent to the dilution of the iron which is then taken, and I have had very good results by giving a single drop of tincture of perchlorid of iron in a tumblerful of water twice or thrice a day. This quantity seems small in comparison with the ordinary doses, but it forms a very strong chalybeate water.

Iron is partly excreted in the bile, and in patients to whom one is giving it, it is advisable to see that constipation does not occur. In this respect some most satisfactory preparations of iron are those in which it is given in combination with an aloetic purgative. In some cases of anemia the addition of a small quantity of arsenic to the iron appears to aid its action, and in other cases manganese, which belongs to the same chemical group as iron, has been employed, either with it or in place of it.

Although the blood maintains equality of composition within narrow limits in health, yet it is constantly varying more or less according to the substances absorbed from the intestine or poured into it in the form of internal secretion or of tissue waste by the various organs of the body. Among the most important of the internal secretions are those of the thyroid and suprarenal bodies. The thyroid appears to dilate the blood-vessels, accelerate the circulation, and increase tissue metabolism, so that the vital processes take place more rapidly, growth occurs in stunted children, the extremities become warm, and nervous action more rapid. The use of this gland in myxedema is one of the greatest triumphs in modern medicine, but it relieves also the contraction of the vessels in Raynaud's disease and in chilblains. When taken in excess, it produces nervousness, excitability, sleeplessness, and tremor—many of the symptoms, indeed, which characterize exophthalmic goiter. Suprarenal gland, on the other hand, tends to stimulate the heart and contract the vessels. It is, therefore, a powerful cardiac and vascular tonic, and may be used in failing conditions of the circulation. Such failure of the circu-

lation is very marked in Addison's disease, and it is in this malady that the extract of suprarenal capsule is of most service, although I have found it useful also to a certain extent in lessening the symptoms of exophthalmic goiter. In this disease, however, the great remedy is rest, continued for several months together.

The coagulability of the blood depends to a great extent on the amount of lime it contains. When the coagulability is too small, as in persons who are inclined to bleed, it may be greatly increased by the free administration of calcium chlorid before an operation. When the coagulability is too great, the amount of lime-salts in the food should be lessened, and especially milk, which contains a quantity of lime, should be omitted from the dietary. It is possible, from the fact of potassium counteracting the action of lime upon muscle, that it may also counteract the effect of lime on the blood and lessen its coagulability, but at present we have no experimental data upon this subject.

Gout and rheumatism are two diseases which are usually attributed to imperfect tissue metabolism, although there is a tendency, in the case of rheumatism, at least, to transfer it to the class of infective diseases. In both of them, whether the cause be microbic invasion or alteration in the ferments produced in the body itself, there appears to be increased tissue metamorphosis with diminished oxidation. In rheumatism the acidity which occurs in the sweat and urine is usually ascribed to the presence of lactic acid, which is a result of the splitting-up of carbohydrates in the body, while in gout the acidity is attributed to uric acid formed from proteins. In both, however, there is deficient oxidation, for lactic acid, which is normally produced in muscles during exertion, ought to undergo combustion and form carbonic acid, while uric acid ought to undergo further change and produce urea—a change which, as already mentioned, may be induced by the normal liver tissue during digestion. In gouty persons, however, hydrocarbons are also liable to undergo imperfect oxidation, so that frequently oxalates or sugar may alternate with uric acid in the urine of gouty people. It is usual to limit the carbohydrates, and especially sugar, in rheumatic or gouty patients who suffer from oxaluria or glycosuria, while in ordinary gouty conditions limitation of proteins is desirable; but even when the patient is liable to well-marked gout, if the transformation of hydrocarbons is imperfect, as shown by a tendency to obesity, the proteins must be given in fuller quantity and the carbohydrates strictly limited. As a rule, oxidases, as those ferments which produce oxidation are now commonly called, act better in alkaline liquids, and both in gout and rheumatism the administration of alkalis or the alkaline salts of vegetable acids are freely used as a matter of empiricism, preference being usually given to potassium or lithium over sodium. How far the beneficial action of salicylates is due to their limiting the splitting-up of proteins or carbohydrates without interfering with oxidation, or how far it may be due to increasing the elimination of waste-products, has not at present been determined, but there can be no doubt whatever of their practical utility in gout and in rheumatism.

Acting on the supposition that their utility in gout is due to their increasing the solubility of uric acid, various substances have been introduced into medicine, such as piperidin, piperazin, lysidine, and other allied substances. The theory of their action may be incorrect, but certainly they seem to be sometimes useful in practice. The power of leukocytes to attack and digest invading microbes has already been mentioned, and one would naturally think that any drug that would increase the number of leukocytes in the circulating blood would be useful in septic diseases. Acting on this assumption, sodium cinnamate has been injected into the tissues or into the blood, and apparently with good result in some cases. At the same time the administration of alkalis, such as sodium, by increasing the alkalinity of the blood, raises its bactericidal power and thus enables the organism better to withstand the disease.

For a long time the mode of action of quinin in malaria and of mercury in syphilis was unknown. We now know that the diseases are due to minute organisms, and that quinin tends to act as a poison to the plasmodium and mercury to the spirochete. Not improbably they also act as antitoxins to the poisons which these organisms produce. As knowledge advances, the number of diseases depending upon animal parasites in the blood is constantly increasing. We are still far behind in the pharmacologic knowledge which would enable us successfully to combat these diseases, but we may fairly trust that, as time goes on, we will find out drugs which will destroy the parasite while leaving the tissues unhurt, and thus treat these other diseases as successfully as we now can treat malaria. Arsenic occasionally proves a most useful remedy in malaria and in many other conditions whose pathology is still obscure, but how it acts in these cases, and why it should be beneficial in skin diseases, in gout, and in phthisis, we cannot yet accurately decide.

The conditions of the muscles have hitherto received but comparatively little attention, and the chief modes of restoring the power to weakened muscles consist in improving the general condition of the blood by iron and other tonics, by increasing the action of the muscles through electric stimuli applied to them or to their nerves, by stimulating the nerve-centers with strychnin, and by kneading the muscles so as to improve the circulation through them. It is worthy of remark that in myasthenia gravis the condition of the muscles is much like that which occurs in poisoning by ammonia, and this fact may possibly point us by and by to the proper method of treatment. In cases of disease of nerve-trunks our knowledge of treatment is limited by our ignorance of pathology and pharmacology, so that at present, in cases of neuritis, the treatment resolves itself into the use of electricity, which we hope, in some rather vague way, will aid the nutrition of the nerves and the administration of remedies intended to counteract rheumatic or gouty tendencies, such as alkalis, potassium iodid, salicylates, antipyrin, and a number of other remedies belonging to the benzin group, such as phenacetin, aspirin, and guaiacol. Sometimes

these may be combined with advantage with potassium iodid, and, in addition, baths, saline or sulphurous, and massage, when the nerve is not too tender, help to restore it to the normal condition.

TREATMENT OF THE CIRCULATORY SYSTEM

The pump which drives the blood on to the tissues is the heart, but, unlike the pipes of a water-supply, the living arteries have a three-fold function: They not only—(1) Conduct the blood and (2) by their contractile power regulate the supply going to any part at one time, but they also (3) aid its onward flow by their movements—so much so that after the heart has ceased to beat they will empty the arterial system, a fact which led the early anatomists to believe that the arteries were naturally filled with air instead of blood. As a rule, the arteries, like the turn-cock in a city, where the water-supply is insufficient, contract and lessen the amount of blood to one part at the same time that they are dilating and allowing more blood to flow into another, for nature is economical, and works with a supply of blood which is insufficient to keep up a lively circulation in all the organs of the body at one time. The splanchnic area, for example, is so large that it will hold nearly the whole of the blood in the body, and the vessels of the muscles, when dilated, will allow as much blood to pour through them in a given time as all the other vessels in the body usually do.

The effect of local contraction of peripheral arteries is well seen in the fingers, which sometimes become pale, cold, and shriveled, like those of a corpse, while the rest of the body is perfectly healthy. This condition, to which the name of Raynaud's disease has been given, occurs to a lesser degree in many gouty people, and is frequently associated in them with the formation of chilblains. A similar condition of peripheral contraction occurs in sick headache, and it is quite possible that it may form a powerful factor in the etiology of many conditions of the body and the mind with which we are not at present able to associate it. It is very apt to come on in gouty people, and may in them be greatly lessened, or completely removed, by anti-gout remedies, such as alkalis or salicylates, but perhaps the most efficacious remedy is dried thyroid gland in the form of tablets. In headaches the vascular spasm may be relieved, and the tendency to return diminished by the continuous use of potassium bromid and sodium salicylate.

Some of the waste-products of tissue metabolism appear to have the power of causing a more or less permanent contraction of the arterioles, and this becomes associated with thickening of the walls, which leads to a very considerable rise in the arterial tension. In elderly people, and especially among those who suffer from chronic interstitial nephritis, this high tension constitutes a great source of danger, as under it vessels are apt to give way and apoplexy to result. It is most important, therefore, to lessen it, and this is best done by putting the patient

on a farinaceous and vegetable diet, avoiding butcher-meat, and giving nitrogenous food, on the whole, very sparingly. At the same time the bowels must be kept freely open, and a mercurial pill given at night, followed by a saline in the morning, twice or even thrice in the week, usually helps very efficiently in keeping the tension down. There are certain drugs which are also useful, among the most important of which are potassium iodid, nitro-erythrol, nitroglycerin, and sodium nitrite. Lately, another drug has been added to our armamentarium by Dr. George Oliver in the form of the hippurates of sodium and ammonium, which in doses of $\frac{1}{2}$ to 1 grain, two or three times a day, tend to keep the pressure down to the normal. The substances which reduce it most quickly are nitrite of amyl and nitrite of isopropyl alcohol. These may be given by simple inhalation from a bottle, or by breaking a glass capsule, in which they may be readily carried about. The sudden reduction in tension which this inhalation effects frequently relieves the intense pains which occur in angina pectoris. In cardiac asthma depending on inability of the right ventricle to drive the blood through the pulmonary area the nitrites sometimes are useful, but not so much as when the resistance is in the general circulation.

We do not yet know the products of the tissue change which cause a general contraction of the arterioles, but many of them probably belong to the purin group. The most marked effects in raising the blood pressure are produced by a substance or substances contained in the suprarenal gland. An extract of this gland has the double action of stimulating the heart to increased activity and contracting the arterioles, so that the tension rises enormously. This effect is, however, only temporary, and is produced only to a very slight degree, if at all, when the substance is taken into the stomach instead of being injected intravenously or subcutaneously.

Extract of thyroid, on the contrary, tends to dilate the vessels so that the surface becomes warm, the skin moist, the tension low, and the pulse weak, and these symptoms occur when the drug is taken by the mouth. The more rapid circulation thus produced appears to make the nervous system more excitable, so that in some cases the medicine has to be omitted, but when there are depression and despondency, the accelerated circulation sometimes gives relief from these symptoms. Raynaud's disease and chilblains are both benefited by thyroid. Local dilatation of vessels is most readily produced by warmth in the form of baths, poultices, and wet compresses, but it can be induced also by local irritation, such as blisters and irritating substances, either rubbed in as liniments or painted over the surface of the vessels to be dilated. Massage will dilate the vessels locally, and may be applied for its action upon the surface or upon deeper organs. When applied to the muscles, it may increase the rapidity of circulation through them as much as threefold, and in this way it is most useful in lessening high tension and in relieving its effects. When dilatation has been produced by the local application of heat, it soon passes off,

but when it has been caused by irritants, it remains for a longer time—indeed, for days together, as may be readily seen by the redness of the skin which supervenes after a blister. Local contraction may be produced temporarily by the application of cold, and also by local irritants not sufficient to cause marked dilatation. The continuous application of cold to a part, therefore, is sometimes useful in lessening inflammation and the pain which results therefrom.

The local application of blisters sometimes has a similar effect in relieving local pain, as, for example, in cases of articular rheumatism, where a strip of blister an inch broad encircling the limb above and below the joint will sometimes produce rapid and great alleviation of pain, as well as initiate absorption of the swelling and restoration of the joint to its healthy condition. It is hard to say in this case how much is due to alteration in the circulation through the joint and how much is due to what may be termed internal secretion, for the effusion of fluid under the epidermis naturally produces considerable change in the fluids which still circulate in the tissues.

In considering the effect of drugs upon the heart it is perhaps easiest to divide them into those which affect its rate, its strength, and its regularity. So long as the vagi are intact, all those drugs which raise the pressure tend to slow the heart, because high arterial tension appears to act as a stimulus to the vagus roots in the medulla, and thus to render the cardiac pulsations slower, while diminished pressure has a contrary effect and quickens the pulse; but a great many of the drugs which cause contraction of vessels have also a distinct stimulating action of their own upon the vagus center, and will thus slow the pulse, even though the pressure be lowered, or would slow the cardiac beats in the excised heart of a frog. The drugs belonging to this group are very numerous—digitalis, strophanthus, convallaria, squill, erythrophleum, adonis vernalis, apocynum cannabinum, spartein, cactina, and a large number of arrow poisons which have not yet been used in medicine. They nearly all have the power of increasing the strength of the cardiac action and contracting the arterioles, but they do not possess these powers in equal degree. Strophanthus, for example, appears more especially to stimulate the heart; erythrophleum, to contract the vessels; while digitalis seems to possess both these actions in a more equal degree than the two others.

In cases in which there is general failure of the circulation and both sides of the heart are weak, so that the arterial tension is low, the venous pressure high, and there is a tendency to edema in the cellular tissue and lungs, and to dropsy of the serous cavities, digitalis, as a rule, is best, But in that very common class of cases, occurring in elderly, gouty men, in which tension is high and the hypertrophied left ventricle is beginning to give way, strophanthus is preferable to digitalis, because it stimulates the heart without producing the arterial contraction which would be inadvisable in these cases, both because it would oppose a greater resistance to the heart and because it might lead to bursting of a vessel and cerebral hemorrhage. In such cases,

then, we prefer to use strophanthus to steady the failing heart, and to combine with it nitro-erythrol or some other vascular dilator to lessen the tension and make the work of the ventricle easy. Strychnin appears to have the power of stimulating the cardiac ganglia without affecting the muscular structure, and it forms a very useful adjunct to digitalis or to strophanthus, which exert their power partly upon the nervous structures and partly upon the muscular tissue of the heart. In cases of threatened cardiac failure the subcutaneous injection of strychnin is one of the most powerful means of recovery which we possess, and in very severe cases as much as $\frac{1}{10}$ grain may be given at once and repeated as necessity demands. Another drug, the action of which is exerted chiefly upon the muscular fiber, is caffein, which seems to strengthen and prolong the cardiac contraction, and is thus useful along with digitalis or strophanthus and strychnin.

One result of the retarded venous flow, consequent upon the failing heart, is congestion of the liver, which not only becomes swollen, but inactive, as shown by the large amount of urates occurring in the urine; for an active liver, as already mentioned, has the power of transforming urates into urea, and thus preventing the deposition of urates. It is probably from some action on the liver that mercurial pill and calomel prove such efficient aids to digitalis and other cardiac stimulants in diseases of the heart, and frequently when all members of the digitalis group, even when combined with strychnin and caffein, have failed to give the relief desired, the patient begins to improve at once when a little mercury is given in addition. A favorite combination which, with slight variations, has held its ground in medical practice for well-nigh two hundred years, is the pill composed of 1 grain of blue mass, 1 grain of powdered digitalis leaves, and 1 grain of powdered squill.

Where the aortic valves alone are incompetent, the patient may feel no symptoms and no treatment may be required beyond a caution to the patient to avoid strain, but when the hypertrophied ventricle is beginning to yield, strophanthus, strychnin, and perhaps also some caffein may be required to steady it. In such cases strophanthus and digitalis must be given with a certain amount of care, as they tend to prolong the diastole, and during this period the tension in the vessels may sink so low as to bring on syncope, with a fatal termination. It is, therefore, advisable not to give these substances continuously, but only for a few days at a time, with intervals between, unless the patient is on his back and the risk of syncope is thus minimized. When the yielding has gone so far as to render the mitral valves too small for the dilated auriculoventricular orifice, and regurgitation thus occurs, treatment must be conducted as though the case were one of primary mitral regurgitation by rest in bed, so as to ease the heart, and by digitalis or strophanthus with blue mass and strychnin.

Caffein and diuretin have the double effect of increasing the cardiac power and of stimulating the kidneys, so as to remove the fluid from

the tissues or serous cavities, and a useful remedy for this purpose is found to be a mixture of potassium tartrate, spirit of juniper, with decoction of broom. Sometimes also spirit of nitrous ether, by dilating the vessels, tends both to relieve the oppressed heart and to increase the urinary secretion. The dose of this drug is usually much too small, and I have seen a patient, apparently moribund, saved by a mistake. The directions given were that he was to have half a dram every quarter of an hour until he had taken two drams, but instead of this the attendant administered two drams every quarter of an hour until he had taken two ounces, the result being that the collapse passed off and the patient's condition for the time was greatly improved.

Irregularity of the heart's action is frequently associated with cardiac disease, and more especially with mitral constriction, and probably depends, in part at least, upon unnatural distribution of pressure in the various cavities of the heart. The various means already discussed for improving the circulation thus tend to render the pulse more regular, but irregular action frequently depends upon some functional nervous condition, which is sometimes reflex from the stomach or other organs, and both an irregular pulse and palpitation are sometimes better treated by bismuth, sodium bicarbonate, and rhubarb, than by digitalis or its congeners. Distention of the stomach, by tilting the heart up, is a frequent cause of palpitation and irregularity. These are relieved by carminatives, such as soda, ammonia, and peppermint, with the result that the cardiac distress and disorder pass off, and, if the flatulent dyspepsia is cured by appropriate treatment, the circulation recovers its normal rhythm.

TREATMENT OF THE NERVOUS SYSTEM

Two of the most important symptoms connected with the nervous system are sleeplessness and pain. It is proverbial that the longest way round is sometimes the shortest way home, and in discussing the pathology and treatment of sleeplessness it may really be best to begin with the vital properties of a simple cell, such as an ameba or a leukocyte, consisting only of protoplasm surrounding a nucleus. This protoplasm sends out prolongations freely in all directions, and sometimes several cells meeting together may become fused in the form of a plasmodium. The activity of the protoplasmic movements varies with different conditions. They are accelerated by heat and retarded by cold, they are quickened by some foreign substances, and lessened or abolished by others. The same drugs which, in minute quantities, quicken their movements, usually retard or abolish them in large doses, and, while moderate heat quickens movement, excessive heat abolishes it either temporarily or forever. The waste-products of tissue change in the cell itself, as they accumulate, lessen its movements and diminish its vitality. A mobile cell, like a leukocyte or ameba, can move away from the spot where its waste-products have

accumulated, just as a nomad moves his tent, but where cells are fixed, the waste-products must be removed from the cell, just as the refuse of cities must be carried away by a system of sewage, while the inhabitants remain in their places.

Now, nerve-cells, although in some respects the most highly developed of all those forming the tissues, are in other respects the most primitive, and this dual condition of a nerve-cell is necessitated by the functions it has to fulfil; for its duties toward the organism are definite and permanent, and at the same time the external conditions under which the organism lives are constantly varying, and an extraordinary amount of mobility in the nerve-cell is required to meet them. We find, then, that a nerve-cell has two kinds of connection: (1) A definite prolongation, or nerve, which undergoes no very evident change during its functional activity; and (2) numerous protoplasmic processes by which connections with other nerve-cells may be established in ways which are so varied that when we consider the number of cells in the nerve-centers, the variations may be looked upon as infinite. It is now generally assumed that the connection between the nerve-cells in the centers is affected by their protoplasmic prolongations. When these are in touch, the nervous force may pass from one cell to another, but when these are withdrawn from one another, the nervous current is at once cut off, just as an electric current is broken by turning a switch and disconnecting the ends of the wire through which the current ought to pass. Such an explanation appears to fit in well with many commonly observed facts, such as that of sudden loss of memory for a name and its sudden return when one is not thinking of it. The loss is explained by the retraction of the ameboid prolongations, so that the current of memory is broken and its re-establishment is effected by the extension of the prolongations, so that they again touch. In old age the prolongations become fewer and less mobile, so that the mental faculties become more limited and more sluggish. Like the leukocyte or ameba, the functions of the nerve-cells can be greatly influenced either by the products of their own waste or even by the products of tissue metabolism in other parts of the body. There is a natural process of self-regulation in the body, by which periods of activity alternate with rest. During the activity of the nerve-cells their waste-products accumulate and tend gradually to diminish the functional activity of the cell until at last it becomes inactive. During the period of rest, these waste-products are either removed or undergo a process of change, whereby their physiologic action is altered from a stimulating to an exciting one, just as the narcotic principle of the poppy, morphin, may be converted into a strychnin-like substance by a simple chemical alteration.

The products of nervous waste are removed by the blood and lymph which circulate through the brain, and these also supply new material to repair the waste of the nerve-cells and oxygen to maintain their functional activity. During sleep, the protoplasmic processes of those cells which keep up connection with the outer world are so

much withdrawn from each other that this connection is broken, while the cells connected with the vital processes of respiration and of circulation continue their work uninterruptedly, and sometimes the cells connected with thoughts and ideas may also be functionally active, as evidenced by dreams. We cannot, as yet, localize these cells anatomically. We may suspect that they are the links between the cerebrum and the basal ganglia, but this is no more than a suspicion, and at present we can only class them more or less vaguely according to their function. The functional activity of the cells which maintain communication between thoughts or ideas and the external world may be excited, and this communication, which has been broken by sleep, may be at once restored by powerful stimulation from without, by a loud noise sounding in the ears, a bright flash of light thrown upon the eyes, or an unwonted or painful stimulus to the surface of the body. All such stimuli tend to maintain the connection between the outer world and the sensory nervous centers, and thus either to awaken from sleep or to prevent sleep from occurring.

Stimuli coming from other parts of the nerve-centers may have effect similar to those coming from without, and painful ideas, anxiety, or even pleasurable excitement may keep up the communication with the outer world and prevent sleep. Functional activity of the nerve-cells is usually associated with a more rapid flow of arterial blood through the brain, and it has been observed by Durham and others that the cerebral arteries dilate at the moment of awakening, while during sleep they become contracted and the circulation through them diminished. In coma the condition of the circulation which obtains in sleep is still further accentuated, so that while the arteries become very contracted, the veins become much dilated and engorged, just as we see in the hands that the first effect of cold is to cause paleness, but later on it produces venous engorgement with blueness. Usually the circulation of arterial blood through the brain is regulated by the contractile power of the arteries, but when arterial blood flows to the brain in large quantity and under high pressure, sleep is more difficult of attainment. For example, when the carotid arteries become atheromatous and thus lose their contractility, insomnia is apt to become a very distressing symptom, and the same thing occurs in cases of gouty kidney, in which the high arterial tension drives the blood forcibly through the brain. External stimuli not only act reflexly upon the tissue change in the nerve-cells, but they tend to cause contraction of arterioles in the body generally, and thus raise the arterial tension. Thus, if the feet are too cold, if the feet are too hot, or if there be any peripheral irritation, painful or even uncomfortable, the tension will rise and sleep be interfered with; but the tension may be increased from the heart as well as from the vessels, and anything that stimulates the heart to excessive action will raise the tension and consequently interfere with sleep. Irritation of the stomach by undigested food, by food that is too hot, by excessive acidity, by tobacco, tea, coffee, or other drugs, will raise the arterial pressure and interfere with sleep.

The effect of blood-pressure on the brain upon the stages of sleeping and waking was well shown by Friedländer. After giving an animal a large dose of isopropylic alcohol, he found that he could determine the condition of sleeping or waking by altering its position. If it were held up by the legs, so as to increase the supply of blood to the head, it at once awoke, but when held up by the ears, it fell asleep.

In treating insomnia, we have, then, first of all, to consider the remedies which bear upon the circulation. When the arteries are atheromatous, we must restore their contractility, if possible, by means of potassium iodid and of massage, and this method is sometimes very efficacious. Under it I have seen the carotids of an old lady which previously appeared to be as hard and rigid as pipe-stems become comparatively soft and elastic, and the patient regained, to a corresponding extent, the power to sleep which she had lost. Where the tension is high in cases of arteriosclerosis or contracting kidney the high-frequency current sometimes reduces it very satisfactorily. If the insomnia be due to autointoxication, the removal by free purgation with magnesium sulphate alone or along with mercurials may be of more service than narcotics.

We must remove sources of local irritation, relieve pain if it be present, warm the feet or other parts of the body by hot bags or bottles, if necessary, or else by friction. In cases in which indigestion produces insomnia, we should give no food during four hours or more before sleeping time, or if this is found to be disadvantageous, the food should be of the lightest description. When flatulence and acidity prevent sleep, some sodium bicarbonate or soda and peppermint are sometimes more efficacious than a sleeping draught. Occasionally, when the whole body gets too hot and the circulation excited, merely getting out of bed and walking a few times round the room to get cool will allow the patient to obtain sleep. When the skin is uncomfortable from dryness, want of elasticity, or the presence of waste-products, a hot bath or hot sponging, followed by very gentle drying, will sometimes bring on sleep. When the feet are persistently cold and not relieved even by a hot bag, putting them in cold water, rubbing them hard until they are red, then drying with a warm, soft towel, may relieve.

The splanchnic area is able to contain a large quantity of blood, and one may sometimes, as it were, bleed into this area and lessen the circulation in the brain by dilating the vessels of the intestine and stomach. This may be done by the external application of a hot bag to the abdomen, or, still better, by a wet compress or by the introduction into the stomach of a little bland, warm food, such as gruel or soup; when patients awake in the middle of the night and cannot get to sleep again, this food may be kept warm at their bedside during the night, so as to be ready at the proper moment, by placing it in a baby's food-warmer. If the food is too hot, it tends to excite the heart, which is divided from the stomach only by the diaphragm, and the local heat passing through and stimulating the heart directly will

raise the arterial pressure and undo the good that might be otherwise obtained by dilating the vessels of the stomach.

When the action of the heart is kept up by a high temperature, as in fevers, sponging the skin with hot water, dabbing it afterward with a soft napkin, and leaving the patient's body exposed under a cradle with only one blanket over it will lower the temperature and bring on sleep. In place of this antipyretics, such as phenacetin, antipyrin, etc., will sometimes act as hypnotics when more purely narcotic substances entirely fail. Chloral hydrate, by its depressing action upon the heart, combined with its sedative action on the nerve-cells themselves, is a powerful hypnotic, either alone or combined with others, and when the tension is high, may be more successful than others which act only upon the nerve-cells.

We must now pass on from the circulation to consider the effect of drugs upon the nerve-cells. Some of them appear to increase the power of the cells to put forth protoplasmic prolongations, while others lessen or abolish it.

Among those which increase the power of the cells to put forth protoplasmic prolongations, or perhaps to prevent their retraction, the most powerful appear to be certain substances nearly allied to uric acid, and belonging to the so-called xanthin group. These are the active principles of tea, coffee, cocoa, Paraguay tea, etc. In many people tea or coffee tends to produce great wakefulness, so that they may either lie quiet in comparative comfort or toss about without any apparent reason; in all such cases it is well for the patient to avoid taking tea or coffee for a good many hours before going to bed. Some people, indeed, are so sensitive that it is unsafe for them to take it later than breakfast time.

Perhaps, in place of drugs, I ought to say chemical substances, for lactic acid, which is a product of muscular waste, appears, according to Preyer, to have a considerable power to lessen cerebral activity and produce sleep without exerting any marked influence upon the circulation. The most abundant nitrogenous product of muscular waste is urea. This, when pure, does not seem to act as a soporific, but some bodies allied to it in chemical composition are powerful and useful hypnotics. The first of those to be introduced was urethane, or perhaps I ought rather to say urethanes, which are compounds of various alcohols with urea. The one to which the name of urethane is given is a compound of ordinary ethyl-alcohol with urea. Another, hedonal, contains methyl- and propyl-alcohols, while one lately introduced, veronal, which is diethylmalonylurea, appears to be the most efficacious of this group hitherto introduced into practice; in doses of 3 to 10 grains it appears to produce refreshing sleep. It is quite possible that bodies belonging to this group are formed in the muscles or glands during their functional activity, and that they may play an important part in inducing natural sleep after muscular fatigue.

As long ago as 1839 Dr. Percy showed that in all probability alcohol has a peculiar affinity for the cerebral substance, as a much

larger proportion could be recovered from the brains of animals poisoned by it than from their other organs. In the compounds of which I have spoken it is not improbable that the alcohol forms a link which binds the urea to the nerve substance. Alcohol itself is sometimes a powerful hypnotic, partly by drawing blood to the stomach and partly by its sedative effect upon the nervous structures themselves. One of the firstfruits of the recognition of the relationship between chemical constitution and physiologic action was the introduction of chloral, by Liebreich. By its double action in enfeebling the heart and thus lowering the blood-pressure, while at the same time lessening the functional activity of the nerve-cells, it is a powerful hypnotic. It has fallen of late years into comparative disuse, on account of the dread of its weakening the heart, but in cases of high tension, as in chronic Bright's disease, its power of lowering the blood-pressure makes it very useful. Three other bodies, in which sulphur is combined with alcoholic radicles, are sulphonal, trional, and tetronal. The tetronal seems to be the least useful and trional is now the most used. They usually produce sleep without any bad effects, but I have seen the administration of a dose of sulphonal followed for a few hours by marked symptoms of disseminated sclerosis. The bromids appear not only to lessen the excitability of those nerve-cells which bring the inner consciousness into relationship with the external world, but to depress nervous excitability generally. They are, therefore, exceedingly useful in many cases, not only in aiding sleep, but in diminishing general irritability of various kinds, and in combination with other drugs, such as chloral, trional, and veronal, or with a more powerful narcotic, such as opium, they are most useful. Valerian is another substance which lessens excitability, and although its mode of action is practically unknown to us, its utility in the excitable conditions known as hysteric is unquestioned. It has no power to compel sleep, but sometimes, when given at night, by lessening nervous irritability, it may induce sleep. The more powerful narcotics, such as opium and its alkaloids, cannabis indica, hyoscyamus, and hyoscin, have a double action, namely, they tend to relieve pain as well as to induce sleep.

One of the great advantages of morphin and hyoscin is that they can be administered so readily subcutaneously, and thus they are rapidly absorbed and their action is obtained quickly and certainly. We do not exactly know where the sensory center for pain is situated in the brain, but we know that painful impressions are probably conveyed, to a great extent at least, by the gray matter, or perhaps by Gowers' tracts, of the spinal cord, and usually originate in some severe stimulus being applied to peripheral nerves. Though it is the application of such a stimulus that generally gives rise to pain, yet pain may be produced by irritation of nerve-trunks, of the spinal cord itself, or of the cerebral center, although there may be no peripheral cause. Thus, in so-called hysteria, pain has been felt in the joints so severe and so persistent as to lead to the limb being amputated, although the

joint was perfectly healthy and no cause for the pain could be assigned except a mental impression on the part of the patient to which the name of "hysteric" is applied. There can be no doubt that not only is there a very great difference indeed between sensibility to pain in different individuals, but even in the same individual, under different circumstances. A local injury which a man in health would scarcely heed or would, indeed, hardly feel, may cause the same man, when broken down by illness, to feel the pain most acutely and express his feelings in terms which those around him think exaggerated. In trying to relieve pain we must, if possible, remove the cause; for if we simply try to deaden the sensation, we may do serious harm to the individual. Pain is nature's warning that something is going on which we ought to avoid. Therefore it is, to a certain extent, beneficial, but when the warning cannot be taken, when the pain continues, it is one of the greatest possible evils that man can experience, and to avoid it death itself will be gladly welcomed. Strong acids and strong alkalis will both destroy the tissues and act as caustics, but the pain produced by the two is very different, that of the alkalis being heavy and dull, while that of the acids is sharp and stinging. In testing the reflex action of the frog, no one thinks of using dilute caustic potash as an irritant to the foot, but uses dilute acid. When the acid is washed off and neutralized, the irritation ceases. This observation may be very useful to us in practice. One of the commonest causes of severe pain is toothache, and this is very frequently, indeed, due to irritation of an exposed nerve by acid substances or acid secretions in the mouth. If these be neutralized, the pain ceases in a marvelous manner, and I have found the prescription of my friend, Sir Dyce Duckworth, exceedingly useful. It consists of a little bicarbonate of soda with laudanum put on a pledget of cotton-wool and introduced into the decayed tooth. Sometimes a general aching of all the teeth is caused by the action of acid saliva upon the teeth just where they emerge from the gums, and this may be relieved or cured by frequently washing the mouth out with a solution of bicarbonate of soda or sucking tabloids of the same substance.

In a paper which I read before the British Medical Association several years ago, I mentioned that increased sensibility to pain may sometimes be due to lessened alkalinity of the blood, and that the administration of alkalis may thus tend to relieve it. The severe pain of gastric or duodenal ulcer may be relieved almost certainly by large doses of an alkali, but as these may tend to soften the tissues of the ulcer and increase the liability to hemorrhage, I usually give, along with bicarbonate of soda, a little chalk to act as an astringent to the tissues, and some carbonate of magnesia to counteract the constipating effect of the chalk. In renal pain, especially where a calculus is present in the pelvis of the kidney, and where the urine at the same time is excessively acid, I think we get relief of the same kind by lessening the acidity of the urine by alkaline bicarbonates, citrates, or tartrates. Pressure upon peripheral nerves, especially when their excitability

is increased by inflammation, produces intense pain, and this may frequently be relieved by fomentations, poultices, or compresses which soften the tissues and thus lessen pressure. These same applications to the abdomen relieve pain, though here their action is probably due, in part at least, to their effect in producing more even and gentle peristaltic movement with relaxation of spasm in the muscular fibers. In the pain of joints a similar relief may sometimes be experienced from their use, but when inflammation has taken place under some unyielding structure, like a tense fascia or in bone, the application of heat, instead of relieving pain, tends to increase it, because the heat dilates the vessels of the part, which thus press more powerfully upon the nerve-fibers and intensify the pain. In such cases ice-bags do more good than hot poultices, and in the case of a tooth, where the pain is due to inflammation in the alveolus, cold to the cheek may relieve a good deal more than warmth, although warmth to other parts may ease the patient by drawing blood away from the tooth. A large number of drugs belonging to the aromatic group have a powerful action as analgesics: salicylate of soda, antipyrin, phenacetin, exalgin, phenalgin, etc. We do not quite know the modus operandi of these drugs, but it would almost seem as if they diffused the painful impression in the spinal cord, so that it no longer reaches the sensorium. Where, however, the impression is so very extreme that it reaches the sensorium in spite of the action of these drugs, they may appear to intensify, rather than relieve, it. This is not very common, but I have seen cases in which it seemed to occur. Where the pain is due to irritation in the cord itself, these drugs appear to be more powerful than morphin or opium, but the most general of all analgesics are certainly opium and its alkaloids. They are frequently applied locally to painful parts before the fomentations, but it is questionable how far such fomentations are any better than those made of plain hot water. It is after absorption and after it has reached the nerve-centers that opium, or its alkaloid, morphin, acts. In most cases all the benefits which opium can confer may be obtained by the use of morphin, and this has the great advantage, as already mentioned, that it may be given subcutaneously and its rapid action thus insured, but apparently this is not always the case, and sometimes opium suits better than morphin. I have found that a most useful way of giving opium consists in mixing half a dram to a dram of tincture of opium or liquid extract of opium with enough water to bring it up to two fluidrams, and inject it into the empty rectum by a glycerin syringe. In one-half to three-quarters of an hour the opium is usually absorbed, and I think relieves pain almost more efficiently and for a longer time than a subcutaneous injection of morphin will do. This method of administration has the advantage over that of the stomach that the opium comes in contact at once with the mucous membranes, and is not diluted by other substances, whereas in the stomach there may be a large quantity of food which interferes with absorption. Some of the most severe pains in the body are due to combined spasm and disten-

tion of hollow muscular organs, *e. g.*, of the stomach and intestines by flatulence, of the bladder by urine, of the biliary ducts or ureters by calculi, of the heart or aorta by high pressure in angina pectoris, and to spasm of the vessels in nervous headache. In all these cases, if the pain be very intense, opium or morphin may be required for its relief, and sometimes, as, for example, in biliary colic, I have seen pain so intense as to resist the action of morphin injected subcutaneously in large doses. In such cases a plan suggested by the late Mr. Morrant Baker is sometimes most useful. A few whiffs of chloroform are given—just enough to put the patient under. The chloroform anesthesia passes into the opium narcosis, and the patient will sleep for hours, unconscious of pain. In the case of angina pectoris the lowering of the tension by vascular dilators, such as nitrite of amyl, nitroglycerin, or nitro-erythrol, generally relieves the pain at the time, and its recurrence may be, to a great extent, lessened by reducing the tension generally through a diet containing but little nitrogen, and by the continuous use of nitro-erythrol or other vascular dilators. One of the newest of those which seem to promise much is the hippurate of soda or of ammonia introduced by Dr. George Oliver. The pain of headache is, I feel sure, from very many observations in my own person, due to what one might term a colic of the arteries in the head, there being peripheral contraction and central dilatation. The quickest way of relieving this is usually by the use of such substances as antipyrin or phenacetin, and their action is rendered more efficacious by the combination of those drugs with small quantities of citrate of caffein. When the headache is associated with sickness, so that these remedies are useless by the mouth, they may be given by the rectum in one or two drams of water. I have found that headaches can usually be not only arrested, but prevented, by a more or less continuous use of bromid of potassium and salicylate of soda, combined with some aromatic spirit of ammonia to avoid depression. There are some headaches where these remedies are of little use, *e. g.*, the nocturnal headaches associated with specific disease, but in these large doses of iodid of potassium are most useful. Occasionally, this drug renders most signal service even when no history of specific disease can be obtained, and in cases where there is much tenderness of the scalp, benzoate of soda, which is nearly allied in its chemical constitution to salicylate, may relieve the pain, while the salicylate is powerless.

As I have already remarked, the sensation of pain may be entirely due to changes in the cerebrum, and there is a condition which is sometimes even worse to bear than pain itself. This condition is mental depression, which is seen in its most pronounced form in cases of melancholia. There can be little doubt that this is frequently associated with imperfect action of the liver, and that a blue pill, succeeded by a saline, frequently removes all trace of the depression, which is very likely due to autointoxication, although we may not know the exact nature of the toxin. Depression and melancholia are often associated also with a feeble circulation and slow heart, and when the con-

dition is very pronounced, the extremities may tend to be cold and even blue. Such drugs as stimulate the heart and dilate the vessels give temporary relief, and on this account patients are tempted to have recourse to alcohol, which certainly eases the condition for the time, but does not cure, and, therefore, requires to be frequently repeated, often with disastrous results. In such cases the circulation may be sometimes reëstablished by the use of cardiac stimulants and vascular dilators, such as nux vomica, the nitrites, and thyroid extract. It is important at the same time to lessen any reflex irritation of the vagus roots and vasomotor center, and this can, to a certain extent, be done by the use of bromids alone or combined with valerian. In cases of nervous excitement, especially of an emotional character, valerian and bromid relieve and sometimes sulphonal is also useful. As irritability is frequently due to a gouty condition, it may often be lessened and the temper of the patient greatly improved by a combination of salicylate of soda with bromids, and if the urine be very acid, bicarbonate of potash in addition may be useful. Nervous excitement is closely allied to insomnia, and the treatment already mentioned for insomnia may be used for excitement generally. Two drugs that are perhaps more useful for excitement than for insomnia are cannabis indica and hyoscyamus. The former drug, however, requires to be used with caution, as an overdose may bring on delirium very like mania, and hyoscyamus or belladonna, when pushed to excess, may cause symptoms of latent mental disease to appear. In two cases, at least, where I have given belladonna for appendicitis, delirium came on before either dryness of the tongue or dilatation of the pupil, and in both these cases I found that there was a history of mental disease in the family. Where there is motor excitement, without well-marked local lesion, as in chorea or in paralysis agitans, general sedatives may be employed, such as bromid and chloral. In chorea the best treatment appears to be perfect quiet and rest for many weeks. Monobromid of camphor, arsenic, and many other remedies have been proposed for the condition, but none of them is so satisfactory as absolute quiet. In paralysis agitans almost the only remedy which is of much good is the subcutaneous injection of hyoscin in doses of $\frac{1}{100}$ grain. Sclerosis in its various forms is very frequently associated with a syphilitic history, and, consequently, iodid of potassium and mercury are frequently given. In some cases they may be of use, but in many others they fail, and the most useful drugs, on the whole, are such substances as antipyrin and phenacetin, which relieve pain, if present, and may possibly be of some service in regard to the motor symptoms as well. Strychnin is largely employed, but it does not seem to be of very much service. Dr. Cash and I found that we were able to produce symptoms of sclerosis in frogs by means of some benzin compounds, and my assistants, Drs. Batten and Bokenham, noticed that a condition of spastic paralysis was produced by antipyrin. The drugs belonging to the benzin group have a tendency to become associated with sulphates and form innocuous compounds, and, acting on the idea

that disseminated sclerosis might be to a great extent of toxic origin, I have given sulphuric acid and sulphates in it with marked success. I have also found good results ensue from a similar treatment in cases of locomotor ataxia and spastic paraplegia. Where the brain has been actually damaged and loss of motor power induced, one can only hope to cause absorption of the clot by aperients and by iodids, and to stimulate the uninjured nerve-cells and fibers by means of strychnin, while at the same time the weakened muscles may be locally strengthened by massage and electricity. But a great deal can be done to prevent paralysis by carefully watching the blood-pressure, as with men advanced in years, and when it tends to rise too much, keeping it down by means of a non-nitrogenous diet, careful attention to the bowels and liver, and avoidance of strain, mental or bodily. Where paralysis threatens from endarteritis, especially of a syphilitic nature, the free use of iodid is indicated, and sometimes, when the iodid alone completely fails, the administration of mercury along with it is followed by most marked improvement. In some cases this treatment not only removes threatened local weakness, but restores the general activity and balance of the brain, which had previously been impaired, as well as removes depression and melancholy.

Both the condition of the nervous structures themselves and of the circulation through them depends greatly upon the purity of the blood, and this again depends upon the freedom with which waste-products are eliminated. On this account, when the kidneys are diseased and the excretion of solids is interfered with, care is necessary in the administration of narcotics, especially opium, as it frequently has a very powerful action, even upon healthy persons, and may produce dangerous, or even fatal, symptoms in doses which would be without risk if the kidneys were healthy. At the same time, in the distressing breathlessness and insomnia of chronic Bright's disease, it may be necessary to run this risk and give opium in fairly large doses, as it sometimes succeeds when other drugs fail, and without it death would be equally certain and much more painful.

TREATMENT OF THE KIDNEYS

The urinary secretion is the chief channel for the elimination of nitrogenous waste from the body. The amount of urine secreted depends much on the rapidity with which blood flows through the kidney, and this again depends upon the arterial pressure. The higher the arterial pressure, as a rule, the more rapid is the secretion of urine, and the smaller the proportion of solids and the specific gravity of the secretion. But the kidney is not a mere filter, nor does it merely excrete nitrogenous waste. It appears to have an important action in tissue change, the nature of which is not fully understood, but, according to Schmiedeberg, this action appears to be capable of being reversed under different conditions; for when blood containing benzoate of ammonia was circulated through the kidney, hippuric

acid was excreted in the urine, and vice versâ, when blood containing hippurates was circulated, the urine contained benzoates. This double action is probably very important in relation to the high arterial tension which exists in most cases of contracted kidney. The most important diuretic of all is water, and usually the ingestion of a large amount of water into the stomach or intestines will induce a copious secretion of urine, but this secretion is greatly stimulated by bodies of the purin group, especially by monomethylxanthin, dimethylxanthin or theobromin, trimethylxanthin, or caffein. A compound of theobromin with salicylate of soda, known under the name of diuretin, and another, known as theocin-sodium acetate, are especially useful. Digitalis and its congeners, as already mentioned, increase the secretion of urine by raising the blood-pressure. As they have the power of contracting the vessels of the kidney, as well as those in other parts of the body, they may, when given in excessive doses, arrest the renal secretion and thus completely stop the flow of urine. Care must be taken not to push their action to this point, and the addition of some nitrite which dilates the vessels without interfering with the stimulant action of the cardiac tonics upon the heart tends still more to increase the amount of urine. As the secretion of urine depends not only upon the actual pressure in the renal vessels, but on the difference between it and the pressure in the urinary tubules, it is evident that, if the ureters are compressed by ascites, etc., the kidneys cannot act satisfactorily until the pressure is removed, either by very free purgation or by tapping. It is easy to alter the reaction of the urine from acid to alkaline by giving either alkaline bicarbonates or alkaline citrates, tartrates, or malates. The vegetable acids in these latter salts undergo combustion in the blood or tissues, and the base is excreted as a carbonate. Where there is acidity of the stomach and acidity of the urine, one may give bicarbonate or carbonate of sodium, lithium, or potassium. Where there is no acidity of the stomach, but acidity of the urine, we may give the tartrates, malates, or citrates, or, as these salts are contained in large quantities in fruit, we may allow the patient to eat fruit freely, provided it does not interfere with digestion.

The reaction of the urine in many healthy people is not only neutral, but alkaline, during the hours of digestion, and especially the digestion of breakfast, so that water passed about 11 o'clock may be turbid with phosphates on account of so much acid being poured into the stomach during the process of digestion. In dilatation of the stomach it is apt to be permanently alkaline. It is not always easy to render the urine acid, and mineral acids seem to be almost useless in this respect. The best of them is phosphoric acid, which can be given in larger doses than most of the others without doing any harm to the stomach. Perhaps benzoate of ammonia is the drug which most easily renders the urine acid. Where alkalinity is due to ammoniacal decomposition, boric acid is useful, and urotropin, which is a hexamethylenetetramin, and is decomposed in the kidney, yielding formaldehyd, is a powerful antiseptic, and thus sterilizes the urine from

the moment it leaves the glomeruli until it is excreted from the urethra. In chronic Bright's disease, where the cortex of the kidney is greatly atrophied, there is rapid elimination of water, with scanty elimination of nitrogen, so that the urine is very copious and of low specific gravity. In such cases the ordinary rule is to give the patients as little nitrogenous food as may be compatible with their nutrition, and especially to give it in such forms as cheese, fish, and fowl, which contain but little waste material, and to avoid strong soups or meat extracts, of which the essential part is waste material, with little or no nutritive power. The amount of waste in thin slices of bacon is very small indeed, or even in a small thin slice of roast meat, so that in many cases these may be allowed in order to vary the patient's diet, and make him more comfortable without doing any harm. But little can be done for the actual condition of the kidney, and the chief care of the physician is to avoid overexertion, chill, or indigestion, which may excite some febrile change in the patient's body, and thus give rise to a sudden increase of metabolic waste, which the kidneys may be unable to eliminate. In one case of gouty kidney which had gone on perfectly well for many years I have seen death occur in five days from attendance at a banquet where the food caused gastro-intestinal disturbance, and in another I have seen the fatal termination follow upon too long a walk in the hot sun. In acute nephritis the chief object in treatment is to lessen the irritation in the kidneys by diminishing the nitrogenous waste and by keeping it freely diluted, by giving an abundance of demulcent drinks, such as barley-water, with complete rest in bed, and sometimes I think I have seen great benefit ensue from cupping, both wet and dry, over the kidneys. In nephritis the usual treatment is to give iron in various forms. Loss of albumin appears to impoverish the blood and produce anemia. The edema which occurs in such cases is probably due to some toxalbumin, for I have seen general edema produced by the injection of antistreptococcic serum. Where the secretion of urine is scanty, the drugs that are usually preferred are salines, such as bitartrate of potash, which tend to wash the kidneys without exerting any local irritant action, and occasionally it is useful to combine with these spirit of nitrous ether and acetate of ammonia, for there is no doubt that, for the present, the treatment of chronic tubular nephritis leaves much to be desired. When uremia supervenes as a consequence of nephritis, convulsions may be treated by the inhalation of chloroform, and a turpentine enema should be at once employed. The wet-pack is useful in equalizing circulation, and at the same time restraining the patient. Where these measures are insufficient, bleeding from the arm, to the extent of 10 to 16 ounces, and the infusion of saline into the veins, subcutaneous tissue, or into the bowel, are occasionally very serviceable.

TREATMENT OF THE URINARY PASSAGES

Antisepsis in the bladder is usually most easily obtained by the administration of such drugs as benzoate of ammonia, benzoic acid, benzonaphthol, salol, naphthalin, boric acid, or hexamethylenetetramin. There are various synonyms for this last remedy—urotropin, aminoform, formin, and cystamin. It appears to break up in the kidney and yield formaldehyd, which is a powerful antiseptic, and thus renders the urine aseptic from the tubules of the kidney downward. In cases where there is much secretion of mucus from the bladder, however, it is frequently necessary to give astringents, such as copaiba, cubebs, cantharides, sandalwood, oil of turpentine, and, if the quantity of mucus be very great and the sepsis very considerable, it may be necessary to wash out the bladder with antiseptic solutions, such as mercuric chlorid, boric acid, etc. The inflammation and nervous irritability excited by the microbes produce frequent and painful micturition. This may be lessened by the injection of a weak solution of antipyrin or cocain, and by administering morphin, belladonna, or hyoscyamus, either by the mouth or, perhaps still better, in the form of suppositories or bougies. In inflammation of the urethra the irritation may be lessened by warm drinks to dilute the urine, by antiseptics, such as urotropin, and also by terebinthinates, such as sandalwood oil, copaiba and cubebs, while the local irritation may be diminished by urethral bougies containing belladonna, opium, or cocain alone, or combined with astringents, vegetable or mineral. In cases of nocturnal incontinence of urine, which is a most difficult matter to treat, good results are sometimes obtained by the free use of belladonna, but frequently this begins to tell only when pushed to such an extent that the mouth becomes dry and the pupil dilated. Until this occurs one cannot be sure that enough has been given. As nocturnal incontinence may be due either to excessive action of the fundus of the bladder or diminished action of the sphincter, a combination of cantharides, which stimulates the sphincter, with belladonna, which lessens the irritability of the fundus, sometimes succeeds when either one or the other medicine would fail by itself.

TREATMENT OF THE GENITAL ORGANS

In septic conditions of the vagina and uterus similar means are adopted as in the case of the bladder, care being taken, as in the nose, that the force with which any liquid is introduced shall not be sufficiently great to drive it into the Fallopian tubes.

The genitals are closely allied to the urinary organs anatomically, and irritation of the bladder or urinary passages by very acid urine may tend to increase the sexual desire abnormally, while alkalis have an exactly opposite effect, and frequently depress the sexual desire so much, especially in gouty people, that they are avoided because they are, as the patients term it, "lowering." Irritation of the genital

centers may also be produced reflexly by cutaneous eruptions, by constipation, by flatulence. Where abnormal genital excitement depends upon these conditions, each must be treated according to the method already described, but, at the same time, the nervous power in the body should be directed elsewhere by careful avoidance of anything calculated to excite sexual ideas, and the blood should be directed to the upper part of the body, rather than the pelvis, by active exercise of the arms. Where the abnormal sexual desire depends upon disease of the spinal cord, antipyrin and similar bodies reduce it. Deficient sexual power may be due to general weakness of the body or of the circulation in particular, and this is to be treated by iron, strychnin, cannabis indica, coca, or damiana, to stimulate the nervous system, and by glycerophosphates or lecithin to supply nervous food, phosphorus, or phosphid of zinc. Spermin, which, according to Puhl, is a product of nuclein, appears sometimes to lessen nervous debility, on which impotence occasionally depends. It may possibly supply material for the spermatozoa. Local stimulation by very acid urine may be brought on by a meat diet or by the use of cantharides.

Amenorrhea is frequently associated with, and probably sometimes dependent upon, anemia, and is treated by salt of iron and manganese to improve the condition of the blood, and by aloes, which has the double action of relieving constipation and stimulating the afflux of blood to the pelvis reflexly, and by various vegetable substances which have an action the nature of which is not thoroughly understood, such as ergot, apiol, senecio, caulophyllin, gossypium, and pulsatilla. Ergot has an undoubted power to stimulate the uterine contractions in labor, and, apparently, is useful also in amenorrhea. When the uterus is contracted, its vessels are more or less sealed up, and therefore ergot and its derivatives, ergotin and sclerotic acid, in large doses are used also to arrest the flow of menorrhagia. Besides these, gallic and sulphuric acid, as well as the salts of iron, are often given internally, while bromids, cannabis, hamamelis, hydrastis, viburnum, and vinca major are used without any very definite notion of their mode of action.

REGULATION OF TEMPERATURE

The skin is a channel for the elimination of water, whose action is, to a certain extent, complementary to that of the kidneys, although its power of eliminating solids is greatly less. In all probability the skin has an internal, as well as an external, secretion, and is a powerful agent in tissue metabolism, as well as a most important regulator of temperature. The skin prevents excessive rise of temperature in the body, first, by its vessels dilating, so that heat is radiated off, and, second, by the water which it secretes evaporating and thus cooling the surface down. In cold weather, on the contrary, the vessels of the skin contract and prevent the blood from reaching the surface so as to get cool. The subcutaneous layer of fat greatly increases the

protective power of the skin in this respect. The vessels of the skin dilate under the influence of heat, and especially of moist heat, either general or local, and those drugs which increase the secretion of sweat also act to some extent as antipyretics and reduce the temperature. A warm bath in fever may act as a very efficient antipyretic, especially in children, and sponging the body in adults, either with warm or cold water, has a similar action. For my own part, I prefer the body of the patient to be sponged with water as hot as the nurse's fingers will bear it, because by this means the vessels of the skin are dilated and the blood courses over the surface. Instead of drying the skin, a dry sponge or soft napkin should simply be passed over it or dabbed upon it, so as to leave it still very moist, and a simple cradle being then put over the patient and covered by a sheet or blanket, the moisture evaporates from the skin into the space thus formed and lowers the temperature. Where this is insufficient, the end of the cradle may be left open and the air in it may be cooled down by an ice-bag suspended in it. Where evaporation is insufficient to reduce the temperature sufficiently, cold affusions or cold baths may be employed, care being taken not to reduce the patient's temperature too low, as collapse might otherwise ensue. In some diseases, such as cholera, the skin may be icy cold and the circulation through it so imperfect that any further cooling agents applied to the surface are unlikely to be of any service. At the same time the internal temperature may be enormously high, and it is possible that if cold irrigation were applied to the bowel by a double tube in such cases, the temperature might be reduced sufficiently to save the patient's life. Among the drugs which increase the secretion of sweat and loss of heat from the body are acetate of ammonia, spirit of nitrous ether, and, to a certain extent, salicylates and allied bodies. The salicylates, as well as quinin, alcohol, and antipyrin, lessen the production of heat in the body, but in the case of many of them the modus operandi is complicated and difficult to define exactly. In all cases care must be taken that the antipyretic is not pushed to such an extent as to bring on collapse.

There are certain centers in the brain, especially in the basal ganglia, and possibly in the spinal cord itself, which have a regulating effect upon the temperature, and it is very probable that antipyrin, phenacetin, and other substances which are related to them chemically have an action upon those centers, more especially as the power they have to induce sleep and relieve pain in certain conditions is so great that they are almost more used now for this purpose than for that of reducing temperature.

The number of such drugs is being constantly increased. New hypnotics, new antipyretics, and new analgesics are being constantly put on the market. All these are made synthetically, and the increasing power which we thus obtain to control disease and relieve pain has all started from the researches, made forty years ago, by Crum Brown, T. R. Fraser, and B. W. Richardson. During the time

which has since elapsed treatment by drugs has become entirely different, and the power of the physician to cure or relieve his patient by their means has been enormously increased, and we may look forward with confidence to an advance much more rapid in the years to come.

In a short sketch like the present it is impossible to cover the whole ground of the action of drugs in disease, but the general outlines which have been given will probably be sufficient to act as a guide to the practitioner, both in utilizing the remedies which he already possesses, and in searching for others which are yet to be discovered.

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THE GENERAL PRINCIPLES OF SERUM THERAPY

By Ludvig Hektoen, M.D.

In this chapter it is proposed to present a brief summary of the general principles that underlie serum therapy.*

THE BASIS OF SERUM THERAPY

In brief, serum therapy is based on the fact that the animal body, in the presence of infection and its effects, has the power to elaborate specific substances—antibodies—that neutralize the toxic microbic products and promote the destruction of the infectious microbes.

Of the fundamental observations leading to the establishment of this important fact, must be mentioned, first, the common knowledge that, in most cases, recovery from an attack of an infectious disease leaves behind a more or less well-marked immunity to further attacks of the same disease. Development of immunity is the natural termination of many acute infectious diseases, provided the infection and its consequences do not destroy the cellular mechanisms of self-healing.

The specificness of infectious diseases in this respect was recognized early. The idea is expressed forcibly by Fuller, writing concerning chicken-pox, in 1730: "The pestilence (chicken-pox) can never breed small-pox, nor the small-pox the measles, nor they the crystal or chicken-pox, any more than a hen can breed a duck, a wolf a sheep, or a thistle figs, and, *therefore, one sort cannot be preservative against any other sort.*"†

Centuries ago eastern peoples practised the inoculation of small-pox by means of variolous matter from mild cases of small-pox, because the disease so produced conferred immunity to small-pox at

* The literature concerning immunity and serum therapy has reached enormous proportions. Behring's Gesammelte Abhandlungen zur aetiologische Therapie der ansteckenden Krankheiten, 1893; Ehrlich's Gesammelte Abhandlungen zur Immunitätsforschung, 1904; Metchnikoff's L'Immunite dans les Maladies Infectieuses, 1901, will interest those who desire to consult the original sources. In this class may be put also A. E. Wright's Studies on Immunization, 1909; R. Muir's Recent Researches on Immunity, Especially in Relation to Diagnosis and Treatment, 1909; and Bordet's Studies in Immunity, translated by F. P. Gay, 1909. Good summaries of the present state of the subjects are given in Kolle and Wassermann's Handbuch d. pathogenen Mikroorganismen, 1906; and by H. T. Ricketts, Infection, Immunity, and Serum Therapy, 1908; W. D'Este Emery, Immunity and Specific Therapy, 1909; Balduan, Immune Sera, 1909; Müller, Vorlesungen über Infektion u. Immunität, 1909; and A. Wolff-Eisner, Handbuch der Serumtherapie und experimentellen Therapie, 1910. In this chapter references are given mostly to certain recent articles.

† Emphasized by the present writer.

the same time as it was milder than the spontaneous disease. The wonderful success of Jenner's vaccination in preventing small-pox by a harmless method naturally paved the way for the thought that vaccination illustrated a general law, and that any dangerous infectious disease might be prevented by the artificial production of a mild and modified attack.

The first attempt in this direction, that is, at protective inoculation, since the advent of modern microbiology was made by Pasteur, in 1881, when he introduced vaccination against anthrax in sheep by means of attenuated cultures of anthrax bacilli. The principle of protective inoculation, that is, of artificial immunization against infectious diseases of known etiology, was then established.

The advent of microbic etiology under the direction of Pasteur and Koch almost immediately placed the study of infectious diseases on a broad, experimental, and comparative basis. Among the many problems that pressed for solution was that presented by the natural immunity of many animals to certain infectious microbes. Its study led to the establishment of the theory of phagocytosis by Metchnikoff,—a theory that has been fruitful of investigation in acquired as well as natural immunity,—and to more and more penetrating studies of the power of the blood and serum of many animals, including man, to destroy pathogenic bacteria (Fodor, Nuttall, and others).

The fundamental problems in specific etiology are not wholly solved by the discovery of the causative agent, however important this step always must be; it remains to explain how normal function and structure are upset by the entrance of the infecting agent into the body. The first real penetration into the nature and mechanism of certain infections came with the discovery, by Roux and Yersin, in 1888, of the toxic substance, toxin, secreted by the diphtheria bacillus, the absorption of which causes the essential disturbances of function and structure in diphtheric infection, a demonstration that Behring has interpreted as the beginning of a new era, characterized by the conception that morbid processes of infectious nature are reactions to the toxic effects of living organisms. It was followed by Behring's great discovery, in 1890, of diphtheria antitoxin. This discovery rests on the fact that susceptible animals may be made to respond to injections of non-fatal, yet increasing, doses of various toxins (diphtheria, Behring and Wernicke; tetanus, Behring and Kitasato; ricin, abrin, etc., Ehrlich) by the production of antitoxin in quantities greater, by far, than are necessary for their own protection; furthermore, that antitoxic serum from animals immunized in this way, when injected into healthy animals, may protect them from any ill effects of the corresponding toxin, and that it may cure animals already suffering from the pathogenic effects of the toxin. Thus, an "innate faculty of the animal organism to develop, in a marvelous manner, its own resources," was turned to the common good. Curative serum therapy was established.

The very first experiments at healing with immune serum were made by Richet and Hericourt,* who succeeded in protecting rabbits against staphylococcic infection by means of the defibrinated blood of a dog that had been injected with staphylococci.

At first it was thought that it would be an easy matter to obtain specific serums for all bacterial diseases by merely repeating in each case the simple scheme just outlined for antidiphtheric serum. These expectations proved to rest on an inadequate basis, as it was soon found that there are different forms of immunity and other antibodies besides antitoxin.

THE FORMS OF IMMUNITY

Antitoxic Immunity.—For a time considerable confusion existed as to just what was meant by the term toxin. Gradually it has become established that toxins, in the strict biologic sense, are soluble substances of unknown chemical structure, of great sensitiveness to many influences, especially thermal and chemical, and possessing a high degree of selective toxicity, which, in practically all cases, becomes manifest only after a certain period of incubation; true toxins also have the remarkable property of inducing, in susceptible animals, the formation of specific antitoxins, the action of which may be demonstrable *in vitro* as well as *in vivo.* Herein toxins present a fundamental distinction from other poisons, such as alkaloids, which, so far as we now know, do not possess the power to induce the formation, by biologic reactions, of antibodies.

Toxins present many points of similarity with organic ferments: both are sensitive, labile substances, and both give rise to specific antibodies in the blood of immunized animals. Toxins may be produced by bacterial, vegetable, and animal cells (bacteriotoxins, phytotoxins, zoötoxins). In the case of bacteriotoxins a distinction is made between the toxins that are secreted freely into the surrounding media by the bacteria that produce them, *e. g.*, diphtheria and tetanus toxins, and endotoxins, which are so firmly fixed to the bacterial body that they are set free only or mainly when the latter is disintegrated. Two of the most important secretory bacteriotoxins are diphtheria and tetanus toxins, with which it is possible to reproduce with great completeness the clinical picture of the disease caused by infection with the respective mother-cells. Bacillus botulinus, Bacillus dysenteriæ, Bacillus typhosus, Staphylococcus pyogenes, Bacillus pyocyaneus, all produce or contain toxins of different kinds of action—neurotoxic, nephrotoxic, hemotoxic, etc.

Ricin, abrin, robin, and krotin are phytotoxins which, in the hands of Ehrlich, were means of the classic experiments that gave us the foundation of our knowledge of the relations between toxins and antitoxins. Of practical importance are the toxins of pollens, which are believed to be the cause of hay-fever, for treatment of which Dun-

* Compt. rend. de l'Acad. de sci., 1888, 107, 750.

bar has introduced a serum which he holds is antitoxic in its nature and mode of action.

In Ehrlich's side-chain theory toxin molecules are assumed to possess two atomic groupings—one by means of which the toxin is attached to the cell, or the antitoxin, and therefore called the haptophore or binding group; and one by means of which the toxin exercises its toxic action upon the cell to which it is bound, and which, therefore, is called the toxophore group. This conception helps one to understand the selectiveness of the toxins, the period of incubation so characteristic of their action, antitoxic immunity, and also the action and formation of antitoxins, by means of which toxins are neutralized chemically.

The essential feature of antitoxic immunity is that the body is protected from the disease-producing effects of toxin. This may result from the absence in the cells of the body of suitable constituents, with which the toxin may unite, or from insusceptibility to the action of the toxophore groups of the toxin,—histogenic or cellular immunity,—or it may result from the abundant presence in the blood of antitoxin,—hematogenous immunity, which is said to be active when it results from reactions in the organism concerned to the effects of the toxin. Active specific antitoxic immunity may result from a spontaneously acquired disease, like diphtheria, or from an experimental infection or intoxication, in which case the reaction may be so controlled as to cause the production of large amounts of antitoxin. On the other hand, the immunity of persons or animals receiving the ready-made toxin by injection of antitoxic serum is called passive; and this is usually much shorter in duration than the active. Other examples of passive immunity are seen in the passage of antitoxin from the mother to the offspring, either by way of the placenta or in the milk.

We know very little concerning antitoxins outside of their specific actions. They are found in the fluids of the body, especially in the blood-serum of immunized animals, which thus are able to transmit some protection to their offspring. They behave in general like colloids, and are evidently large molecules, because they do not pass through fine filters and dialyze very slowly. They are susceptible to the action of heat (60°–70° C.) and light, but not so much so as the toxins; when dried, they withstand higher degrees of heat and may be kept for a long time.

The Neutralization of Toxin by Antitoxin.—The early explanations of the action of antitoxins were largely vitalistic. The idea once advanced that antitoxin is a changed toxin fell to the ground in view of the fact that the amount of antitoxin produced on immunization is out of all proportion to the amount of toxin injected. There is no reason to believe that the antitoxin directly destroys the toxin, because in certain instances it is possible to recover the toxin from harmless toxin-antitoxin mixtures. At the present time the neutralization of toxin by antitoxin is regarded as the result of chemical union

or physical absorption. The quantitative study of toxin and antitoxin was furthered greatly by Ehrlich when he selected for this purpose certain toxins that exert their toxic action *in vitro* as well as *in vivo*. In this way were overcome some of the difficulties presented by the use of living animals, which is necessary in the study of diphtheria toxin and antitoxin, etc. The substances whose effects are followed easily in the test-tube are certain blood-laking toxins of bacterial origin, hemolysins like tetanolysin, staphylolysin, and others, and their antitoxins; certain vegetable agglutinins for red corpuscles (ricin, abrin, crotin, robin), as well as agglutinins for bacteria, and their anti-agglutinins, and certain ferments that give rise to antiferments. In experiments with the hemolysins and antihemolysins red corpuscles freed from all traces of serum by washing in NaCl solution are used as indicators of the toxic and antitoxic effects of various mixtures, the amount of laking that takes place being easily measured. In this way we have learned that toxic and antitoxic action may take place without the direct coöperation of the living organisms. The rapidity with which toxin and antitoxin unite has been found to depend on the degree of concentration, the temperature, the medium, the amount of salts present, etc.

One of Ehrlich's achievements is the demonstration that there is no fixed relation between the toxicity of diphtheria toxin as represented by the soluble products of diphtheria bacilli in broth cultures, and its power to combine chemically with diphtheria antitoxin. Various influences—time, heat, light, etc.—reduce its toxicity without altering its power to combine with antitoxin. Toxin so changed has been called toxoid. This being the case, it became necessary to establish an arbitrary standard of antitoxin, which is a stabler body, by comparison with which other antitoxic serums might be standardized (p. 289). An accurately tested serum has been prepared for preservation by careful drying, and is now used for a standard. As to the antitoxin unit or immunity unit, he established that quantity of antitoxic serum that will neutralize 100 minimum lethal doses (MLD) of toxin for guinea-pigs weighing 250 grams. Two important limits (limes) were also established: (1) L°, by which is meant the amount of toxin that exactly neutralizes one immunity unit of antitoxin; and (2) L+, by which is meant the amount of toxin that will neutralize one unit of antitoxin + the amount necessary to kill a guinea-pig weighing 250 grams in four days.

Ehrlich now showed that when the L° quantity of toxin is partially neutralized by adding fractional amounts of antitoxin, there is at first no decrease of toxicity in the mixtures, as there should be if the true toxin were bound by antitoxin. Evidently, the diphtheria poison contains certain substances that are non-toxic at the same time that they bind the antitoxin with greater avidity than the toxin proper. The body which has the greatest affinity for antitoxin is called by Ehrlich *prototoxoid*. It may require as much as one-fourth of the immunity unit to saturate the prototoxoids in the L° dose of poison.

From now on the toxin diminishes in toxicity in exact proportion to the amount of antitoxin added. When, say, two additional fourths of the antitoxic unit have been added to L° of toxin, the mixtures no longer produce acute death, but do produce local edema and later paralysis, which is accounted for by Ehrlich as due to another toxic body with less affinity for antitoxin than toxin and prototoxoid; this he designates as *toxone*. The difference between toxoid and prototoxoid is this: that prototoxoid has a stronger avidity for antitoxin, while toxoid in this respect equals toxin proper. Both toxoid and prototoxoid are without active toxophore groups.

Ehrlich's explanation of the fact that a certain amount of antitoxin may be added to the crude diphtheria poison without lessening its toxicity has been accepted generally. His belief, however, that the poison contains two distinct kinds of toxins, namely, the diphtheria toxin proper and toxone, has been attacked by Arrhenius and Madsen, Bordet, and others. These investigators claim that the reactions between toxin and antitoxin are reversible and follow the Guldberg-Waage law of mass action. Hence there will always be some free toxin present in toxin-antitoxin mixtures, and the toxic effect ascribed by Ehrlich to toxone is, according to Arrhenius and Madsen, due to small amounts of free toxin.*

Antibacterial Immunity.—Many important pathogenic bacteria, like the cholera germ, the typhoid bacillus, the pneumococcus, the streptococcus, etc., do not secrete specific toxins like the diphtheria and the tetanus bacilli, at least not to any such extent. The sterile filtrates of the first-mentioned organisms have little or no toxic powers; at all events, specific effects cannot be obtained to any noteworthy degree from these filtrates. On the other hand, the bacterial bodies, especially in the case of typhoid and cholera bacteria, are highly toxic. In these cases the poison appears to be attached firmly to bacterial cells, being freed only as the cells disintegrate. These poisons are called endotoxins; they are as yet poorly understood, and it has not yet been shown that all are true toxins, because of the failure in many cases to find any anti-endotoxin in immunized animals. Many consider that it is the liberation of endotoxins as the bacteria in question disintegrate within the body that causes the toxic symptoms in these infections, as it is not believed that bacterioproteins, which are common to all bacteria, can cause specific symptoms, but only certain common effects, such as inflammatory changes, fever, etc.

As immunity to typhoid, cholera, and other bacteria of this general class becomes established, there appear in the blood newly formed antibacterial substances (lysins, opsonins, etc.), and inasmuch as this appears to be the principal, tangible, new property, the immunity in these cases at present may be regarded as *antibacterial* or *antiinfectious* in its character. It should be noted that immunization with the

* See H. G. Wells, The Present Status of Our Knowledge of the Chemistry of the Processes of Immunity, Arch. Int. Med., 1908, i, 262.

bacterial substances proper, even of toxin-producing bacteria, as a rule, gives rise only to antibacterial substances and not to antitoxins. The serum of animals with an active antibacterial immunity may produce, on injection into other animals, well-marked passive immunity, manifested by—(*a*) Protection from subsequent infection; and (*b*) healing of existing infection. Antibacterial immunity is quite as specific as the antitoxic, but antibacterial serums, as a rule, are not nearly so potent in human infections as the antitoxic. In a number of infections, as, for instance, those caused by streptococci, staphylococci, gonococci, anthrax bacilli (especially in dogs), etc., it is probable that the destruction of the bacteria is accomplished mainly by opsonification and phagocytosis, and that in immunity these functions are intensified by the new production of specific opsonins. This special form of immunity might be spoken of as *phagocytic immunity*, but hard-and-fast lines cannot be drawn between this and antibacterial immunity, because the difference in the nature of the reactions is quantitative rather than qualitative. Antimeningitis serum appears to destroy the meningococcus directly, and to cause increased phagocytosis and intraphagocytic digestion, as well as to neutralize endotoxin (Flexner and Jobling*).

Lysins and the Mechanism of Lysis (Bacteriolysis, Hemolysis, etc.).—Lysis, or the solution and destruction of cells by normal and immune serum, is a more complicated process than the neutralization of toxin by antitoxin, but the underlying conception as to the nature of the action is the same. R. Pfeiffer was the first to show that when cholera germs are placed in the peritoneal cavity of a guinea-pig immunized to cholera, the bacterial cells undergo lysis—*Pfeiffer's phenomenon*. Before long similar observations were made with respect to typhoid, pest, and other bacteria. This reaction is strictly specific. The microbes become immovable, swell up, and form balls that gradually melt away. In most cases, if not all, phagocytosis is observed at the same time, especially, when the destruction is slow. Pfeiffer further showed that the same result occurs when cholera germs are placed in the body of a normal guinea-pig, provided they are mixed with the serum of an immune animal. Pfeiffer's phenomenon is very striking. As stated, Pfeiffer's antibodies, as he called the active substances in his immune serum, are strictly specific. C. Fraenkel's claim that the immunity established by the injection of cholera bacteria, for instance, is not specific, but a non-specific immunity to bacterial proteins in general, has been disproved by Pfeiffer and his coworkers, who show that Fraenkel's protein immunity is in reality only an increased general resistance, which may be produced by a variety of substances (urine, tuberculin, serum, blood, etc.), which quickly subsides, and which does not give the serum of the animal used the power to protect other animals. Pfeiffer at first believed that his antibodies could be activated only by something in the body of living animals, but Metchnikoff and Bordet demonstrated that the

* Jour. Exp. Med., 1908, x, p. 141.

destruction of cholera and other bacteria may be studied readily *in vitro* by adding normal serum to immune serum.

The study of bacteriolysis received great support from the discovery, by Bordet,* that immunization, that is, repeated injection of an animal with the red corpuscles of another animal, gives rise to the appearance in the blood of the immunized animals of a specific substance that causes laking of the red corpuscles injected, just as an immune bacteriolytic serum causes lysis of the bacteria used as the antigen. The great ease with which experiments in hemolysis are conducted, the laking being the indicator of lysis, has made the study of hemolysis a favorite one for the clearing up of many problems in this field.

Specific lytic substances also exist for other animal cells, such as spermatozoa, nerve-cells, leukocytes, etc. Fodor, Nuttall, and Buchner were the first to study the bactericidal and bacteriolytic action of the blood-serum and other fluids of normal animals. Buchner regarded these substances of the serum as the principal protective agents of the body against infection, and for this reason he named them alexins (*ἀλέξειν*, to guard). He regarded the alexins as simple substances. There is no concordance between natural immunity and the bactericidal power of the serum, as now understood. Thus, human serum is strongly destructive of typhoid bacilli, and yet as typhoid fever establishes itself there develops a typhoid bacillemia. On the other hand, dog serum is not anthracidal, and, nevertheless, the dog is naturally immune to anthrax. Other examples of similar bearing might be cited.

The contention of Baumgarten and his pupils, Fischer, and others, that the destructive action on bacteria of normal and immune serum does not depend on special substances, but on purely physical factors, especially osmotic disturbances, and on lack of assimilable food substances, has had to give way to the many accumulated facts in favor of specific action. Neither has it been possible to explain bacteriolysis as the result of alkalinity, which, however, may play some rôle in the process.

Lytic serum, as a rule, owes its power to cause lysis to two distinct but interacting substances—one that, as a rule, is destroyed by heating at 55° C. for thirty minutes,—the complement,—and one that is more thermostable (Bordet). Serum that has lost its lytic power, on account of destruction of the complement by heat or otherwise, is said to be inactivated; it may be reactivated by the addition of fresh serum containing the suitable complement. The thermostable body, most commonly called immune body or amboceptor, is the one that is produced in a specific manner during immunization. Amboceptors are assumed by Ehrlich's theory to be free cell-receptors, which, however, differ from antitoxins in having two groups—one by means of which they unite with the corresponding bacterial or other cells—the

* The same discovery was made by Landsteiner and by v. Dungern quite independently.

cytophile group; and the other by means of which they unite with the thermolabile substance just mentioned, and commonly called complement—the complementophile group. In itself the amboceptor is without any destructive action. Not all bactericidal serums lose their power on heating at 56°–60° C.; some retain it even at 78° C.*

The indications are that not only may the same serum contain several amboceptors, and that the amboceptors in different serums differ, but also that amboceptors capable of uniting with the same cell, bacterial or otherwise, may differ in two respects, namely, in their cytophile and in their complementophile groups.

Occasionally a serum is found that contains amboceptors for a certain kind of cell, but not any suitable complement, as in the case of dog blood, for instance, which contains an amboceptor readily taken up by anthrax bacilli; the complement necessary to complete the lysin may be found, however, in some other animal, as the rabbit.

Amboceptors are fairly stable bodies. Heating at 60° C. for several hours does not have much effect, but heating at 70° C. for one hour usually destroys them. They are non-dialyzable and may keep for a long time.

The complements are sensitive, ferment-like substances, normally present in the blood, and they do not seem to be increased by immunization with foreign cells. Whether blood contains many kinds of complements, or merely a single one, has long been a question at issue between Ehrlich and French investigators; certainly the complements in different bloods differ as to the affinities of their haptophore groups. Complements in general are neutralized by various salts in dilute solutions, so that there seems to be a close relationship in their physicochemical properties. Now, when the proper complement is attached to a red corpuscle or a bacterial cell by means of the amboceptor, it causes lysis, that is, destruction of the cell, cytolysis, by virtue of the action of its zymotic group. Complements, then, resemble toxins in that they have two atomic groups, haptophore and toxophore or zymotic. The toxophore group may be destroyed or rendered inactive, while the haptophore group still retains the power to unite with the amboceptor; the complement is now said to have changed into complementoid.

Insufficient Complement; Deviation of Complement; Complement Fixation.—Lytic serums owe their power to the conjoint action of complement and amboceptor. It has been thought that in many cases the failure of bacteriolytic serum to accomplish expected results is due to lack of suitable complement in human blood for the specific amboceptors produced by immunization of animals. Consequently, it has been suggested that the amboceptors should be secured by immunizing animals closely related to man; that normal serum should be injected with the immune serum, etc. Shiga ascribes the good effect of his antidysenteric serum to the fact that human serum contains suitable complement for the amboceptors in horse serum.

* Hamilton, Jour. Infect. Dis., 1908, v, 570.

Under certain circumstances when amboceptors are present in excess the complementophile groups of the amboceptors may unite with the complement to such an extent that lysis is markedly diminished, if not suspended entirely, because of the lack of complement for the amboceptors that have become attached to the cells. This phenomenon was described by M. Neisser and Wechsberg, and is known as deviation of the complement. According to Bordet's theory, the amboceptor modifies in some way the cells, so that they are rendered susceptible to the action of the complement, which he thinks does not unite with the amboceptor, but the phenomenon of deviation of the complement by free amboceptor does not seem to harmonize with Bordet's conception of the mode of action of the amboceptor.

The disappearance of free complement in a mixture of antigen and antibody (Bordet-Gengou phenomenon) is often spoken of as fixation of complement. The condition of the complement in such mixtures is determined by adding erythrocytes and a specific lytic amboceptor for them; now, if the complement has been fixed, there will be no hemolysis. This indirect way of testing for the presence of antibody or antigen has been applied to infectious diseases and especially to syphilis (Wassermann's test).

Opsonins and Phagocytosis.—According as stress was placed on phagocytosis, on the one hand, and on antibodies, antimicrobic as well as antitoxic, on the other hand, investigators until but recently were largely partizans of either the phagocytic or the humoral theory of healing and immunity. But the sharp antagonism between the adherents of these theories has subsided, because it is now clear that neither mode of action is accomplished without the coöperation of cells and fluids. This is particularly true and easy of demonstration in the case of phagocytosis. Metchnikoff, by broad comparative studies, established the general occurrence and the significance in health and disease of phagocytosis in the higher as well as in the lower animals, and Denys and others have shown that the fluids of the blood play an essential part in the phagocytic process by so acting on microbes and other elements that they are made susceptible of phagocytic action. This property of the blood-fluid is now ascribed to definite substances, the opsonins of Wright and Douglas * and the tropins of Neufeld,† both in all probability the same substances, and destined, I believe, to bear the name of opsonins, at least in the English language.

It is generally accepted that phagocytosis of many bacteria—and also of red blood-corpuscles, which are highly serviceable objects for the study of certain problems—is dependent on substances—opsonins—which become attached to the bacterial cells or corpuscles, as the case may be, and so alter them that they are readily taken up by the leukocytes. Leukocytes, carefully freed by repeated washings in salt solution from the fluids in which they naturally exist, have but very little or no phagocytic power with respect to certain bacteria or

* Proc. Royal Soc., 1903, lxxii, 357; 1904, lxxiii, 128.

† Deut. med. Woch., 1904, xxx, 1358; Centralbl. f. Bakt., 1905, xxxvii, 456.

corpuscles suspended in salt solution, while the same bacteria or corpuscles, after having been treated with suitable opsonic serum and then freed from the serum, are taken up by serum-free leukocytes. A few bacteria, however, *e. g.*, influenza bacilli, are readily phagocytable without the presence of opsonic serum.

Bacteria or corpuscles are not necessarily altered in opsonic serum, and many bacteria, notably streptococci, pneumococci, anthrax bacilli, as well as others, grow freely in such serum. Heretofore the belief that phagocytes may cause destruction of bacteria rested largely upon more or less convincing morphologic appearances. By means of the plate method for demonstrating bactericidal action it has now been shown conclusively that certain bacteria that do not suffer demonstrable injury by blood-serum alone, such as those just mentioned, undergo intraphagocytic destruction when put into mixtures containing living leukocytes and opsonically active serum. In serum alone and in suspensions of serum-free leukocytes active growth occurs, but when the two are mixed, destruction takes place, other factors being equal, in proportion to the number of leukocytes present. The actual demonstration of phagocytic annihilation of bacteria, formerly so often demanded by the opponents of the phagocytic theory, is here furnished.

The indications are that various opsonins with more or less well-marked specific affinities occur in all animals down to and including the echinoderms, being, like other antibodies, present to a variable extent in normal blood and other fluids.

The phagocytic and bactericidal powers of leukocytes may be below the normal in certain infections, especially long-continued streptococcus and pneumococcus infections. This change, which seems to be specific with respect to the infecting coccus, appears to be due to alterations in the fluid parts of the blood, which in chronic pneumococcus endocarditis may contain substances that neutralize the property of normal serum to promote intraleukocytic destruction of pneumococci (Rosenow). In typical pneumonia the leukocytes may be more actively phagocytic than normal.

At first opsonins were regarded as substances of a relatively simple structure, quite easily destroyed by heat (60° C. for fifteen to thirty minutes) and other agents. But it has been found that in many cases the total opsonic effect of fresh serum is the result of the combined action of two bodies, one relatively resistant to heat, the other easily destroyed by heat. The heat-resistant element is capable of opsonic action by itself, and seems to unite quite firmly with the object upon which it acts; the opsonic effect as measured by the resulting phagocytosis is, however, greatly promoted on the addition of the other, thermolabile element, which alone has no opsonic power.* In other words, opsonins, as a rule, seem to have the same duplex constitution as the lysins, with which they are held by some to be identical.

* Dean, Proc. Roy. Soc., 1907, lxxix, 399. Cowie and Chapin, Jour. Med. Research, 1907, xvii, 95 and 213.

The heat-resistant opsonic element appears to attach itself firmly to the bacterium or corpuscle on which it acts because, in some instances at least, it is not detached even after many washings of the opsonified bacteria or corpuscle in large quantities of salt solution. Consequently, opsonification is to be regarded as the special action of a distinct unit, and not as the result of the influence of plasma or serum as a whole. The thermolabile, activating element, however, according to the results of recent experiments, probably remains free in the fluid of the phagocytic mixture, and there is good room still for question as to whether its effect is exercised on the phagocytable object or on the phagocyte.* Years ago Metchnikoff expressed the view that serum may stimulate leukocytes and other cells directly to phagocytosis, while, on the other hand, bacteria or red blood-corpuscles, that take up what he and his followers then called "fixateur," are thereby made phagocytable. It is not impossible that further analysis of the mechanism of phagocytosis will lead to this as the final result. In the light of this possibility opsonins, that is, the heat-resistant opsonic element, may be conceived as having a structure similar to that of agglutinins and precipitins, and to possess two groups, namely, a haptophore, by means of which they attach themselves to bacterial and other cells, and a functional group, by means of which they produce some change in the cell that renders it suitable for phagocytosis. At all events the failure to recognize the interaction of the two elements in the opsonic function of serum and the great difference in their combining properties is responsible for much of the divergence in the earlier results.

While normal blood contains only comparatively small amounts of heat-resistant opsonic substances, each unquestionably possessed of more or less well-marked special affinities, the blood in conditions of acquired immunity may be richly charged with newly formed thermostable opsonic substances, with marked specific affinity for the object against which the immunity is directed. Injections of suitable animals with bacteria or with alien red corpuscles cause specific opsonins to form; in human beings new opsonins arise as the result either of spontaneous infections or of the artificial introduction of killed bacteria and various bacterial products.

The opsonin content of a fluid, such as serum, may be measured more or less accurately either by means of the opsonic index of Wright or by determination of the highest dilution at which opsonic effect is still obtainable, and comparing it with the normal standard. Speaking broadly, Wright's index with respect to a given bacterium is obtained by comparing the number of bacteria taken up under the influence of a serum with the number taken up under the influence of the corresponding normal serum under conditions as nearly comparable as possible.†

* Hektoen, Jour. Infect. Dis., 1909, vi, 66.

† An elaborate and detailed account of the technic of the index is given by Sanborn in Crandon's Surgical After-treatment, Philadelphia, 1910. The dilution method is advantageous in certain cases because it gives a much larger scale.

Whether the opsonic action is caused by distinct and independent substances or by antibodies with other actions as well has been an interesting question, concerning which there is still difference of opinion. The question now seems to be narrowed down to whether the opsonins and lysins are the same, some, as, for instance, Neufeld, claiming that opsonification merely is the result of an early stage of lysis before actual solution takes place. Opsonins would appear to be distinct from other antibodies because a given serum may be opsonic, but not lytic, while the reverse probably also occurs. But here certain difficulties arise. While it is well established that serum may be strongly opsonic without being lytic, and without even containing lytic amboceptor, so far as our present methods indicate, the suggestion is made that in such cases the failure to obtain lysis may be owing to the state of the object tested and not to the absence of lysins. This consideration applies with most effect to instances in which we know the bacterium or corpuscle is susceptible both to lysis and to opsonification, and in which lysis might not take place either because the serum was not active enough or because of some special resistance to lysis. The explanation falls short, however, when applied to bacteria like pneumococci and streptococci, which, while readily opsonified, are yet practically insusceptible to lysis. In this case the claim that lysis does not take place because of the physical state of the bacteria is an assumption.

If opsonification and lysis depend on the same body, the opsonic and lytic powers of the serum of an animal in the course of immunization should always run parallel. If they do so, that fact does not of itself prove that it concerns one body, but failure to run fairly parallel would indicate the existence of separate bodies with different functions. Actual observations show that in certain animals single injections of alien red corpuscles may increase the opsonic power of the serum for that corpuscle a hundred times or more above normal, while the lytic power of the same corpuscle may be increased comparatively much less and in some conditions not at all. On this account, then, as well as for other reasons, the view that opsonins, meaning thereby the thermostable opsonic substances, constitute a distinct class of antibodies, seems to me to be correct.*

That the activating or complementing opsonic substance is closely related to the complement of lysis is indicated by a number of considerations: Both are sensitive to the action of heat, being destroyed by an exposure of thirty minutes to 58°–60° C.; both appear to be split up into two distinct components by water, and both are neutralized by a number of ionizable salts. As stated before, the opsonic complement, however, seems to remain free in the phagocytic mixtures, whereas the complement of lysis is regarded generally as bound by the amboceptor.

Adaptation and Resistance of Pathogenic Micro-organisms to the Anti-infectious Mechanisms of the Animal Body.—Since the dis-

* Jour. Infect. Dis., 1909, vi, 78.

covery of the microbe carrier the adaptation of microbes to the defensive mechanisms of the animal body acquires new interest. Under the conception that phagocytosis and bacteriolysis form the basis of healing and immunity in many infectious diseases, the infecting microbes should disappear at the time of recovery. This is probably the general rule, but there are many exceptions illustrated by the now familiar "*bacillus carrier*." The body may overcome the disease, but not the cause, which may persist in spite of the increase in antibodies. The disease subsides, the disturbances are smoothed away, and yet the germ lives on in the host, apparently harmless and unharmed, sometimes for remarkably long periods. But the equilibrium is not always a stable one; the immunity of the host may give way, and recurrence develop; or the resistance of the germ may weaken, and eventually complete destruction and final elimination take place.

Germs isolated from typhoid and cholera carriers have been found in some cases to offer special resistance to antibodies, including opsonins, but the mechanisms of this mutual immunization of microbe and host are still obscure.

The relapses in relapsing and related fevers are ascribed to the survival in each attack of a few spirilla, which, having become immune to the antibodies of the host, give origin to new "serum-fast" strains that continue the relapses.

Highly interesting conditions are found in certain chronic infections of the urinary tract with bacilli of the colon group; apparently the infecting bacillus may partially immunize itself, in one case to the lysin, in another to the opsonin, in the patient's blood, or else the amounts of different antibodies may vary greatly in the different cases.*

In Metchnikoff's original doctrine of phagocytosis in infectious diseases it is held as a fundamental tenet that as a microbe grows in virulence its resistance to phagocytosis increases. Recent experiments give results in complete harmony with this teaching. On analysis the resistance of certain highly virulent bacteria to phagocytosis is found to depend on insusceptibility to opsonic action, owing apparently to lack of affinity for the opsonin. As pneumococci, streptococci, and other bacteria on successive passages through suitable animals become more and more virulent for these animals, they at the same time acquire a parallel increase in resistance to phagocytosis. When cultivated outside of the body, reversion readily takes place to less virulent states, associated with a returning affinity for opsonin and an increased susceptibility to opsonic action. Investigating this property of pneumococci to develop such strong defense against phagocytosis, Rosenow † found that extraction or autolysis of virulent pneumococci brings into solution a substance or group of substances that neutralize the pneumococco-opsonin in human serum, but not the other opsonins. After extraction of this substance, "virulin," which is thermostable and insoluble in alcohol or ether, virulent pneumococci

* Davis, Jour. Infect. Dis., 1909, vi, 224.

† Jour. Infect. Dis., 1908, v, 285.

unite with opsonin and become phagocytable, while avirulent pneumococci, on treatment with extracts of virulent strains, not only become resistant to phagocytosis in the test-tube, but also to some extent virulent for animals. Entirely independently, Tchistovitch and Yourevitch * appear to have reached identical results on all points, except that they did not study the virulence of avirulent pneumococci after treatment with extracts of virulent strains; and Tchistovitch † has demonstrated that virulence of the bacillus of chicken cholera depends on a similar but specific substance. The Russian investigators name this substance "antiphagin." These antiopsonic substances are wholly different from the "aggressins" of Bail, which appear to be free molecules of bacterial protoplasm having the power to combine with opsonins in a specific manner, and thereby to promote infection.

The Persistence of Immunity.—The antibodies that develop in various infections disappear from the blood in a comparatively short time, and, nevertheless, the immunity to new infections appears to last for years. In actively immunized animals immunity may persist after the new antibodies appear to have passed out of the blood. This immunity is explained by changes in certain cells. Metchnikoff has suggested that it is due to permanent increase in the phagocytic powers of leukocytes. A better supported explanation attributes the immunity to an acquired sensitiveness of cells to the stimuli of the antigens of the bacteria concerned, whereby the cells are able to respond to new infections with an unusually prompt and rapid production of antibodies (von Dungern, Wassermann, and Cole). Von Dungern found that animals once immunized with a special serum, and the resulting specific precipitins having disappeared, responded to new injections of the same serum with a more rapid and more abundant production of precipitins than normal animals. Cole ‡ confirmed this interesting observation as regards the production of typhoid agglutinins by rabbits once immunized. Shiga made the following experiment on himself: He had had typhoid fever twelve years previously. At the time of his experiment his serum did not agglutinate typhoid bacilli. The injection of antityphoid vaccine (autolyzed cultures) was followed by much higher agglutinating and bactericidal powers in his serum than in the serum of the control person who received twice the dose of vaccine that Shiga did. Hence acquired immunity appears to be histogenic in its nature, and may depend on the power to produce antibodies promptly and rapidly. In the case of organisms with definite points of entrance, it has been suggested that the local cells may retain this power, as, for instance, the intestinal epithelium and lymphatic tissue, as a consequence of typhoid fever.

Anaphylaxis.—A condition of hypersusceptibility, or anaphylaxis, results from the introduction into the animal body of a variety of foreign protein substances, such as serum, egg-white, bacterial and

* Ann. de l'Inst. Pasteur, 1908, xxii, 611. † *Ibid.*, 1909, xxiii, 834.
‡ Zeit. f. Hyg. u. Infektionsk., 1904, xlvi, 371.

vegetable proteins. The "serum disease"* which follows injections of horse serum (see the chapter on Treatment of Diphtheria), the tuberculin and mallein reactions, the reaction on injection of gonococcal vaccine in patients with gonorrheal arthritis, are all examples of anaphylaxis. These reactions are regarded as the result of the setting free of toxic substances by the prompt action of specific immune antibodies of the infected body on the corresponding antigen (tuberculin, mallein, gonococcus vaccine). The markedly toxic action of horse serum on guinea-pigs previously injected with horse serum—the "Theobald Smith phenomenon"—has been and is being studied very extensively. Anderson and Foost† present the following conclusions in regard to anaphylaxis in the guinea-pig, which seem to me to be quite generally applicable. Hypersusceptibility to a foreign proteid consists in an increase in the normal power of assimilating this proteid, especially an increase in the rapidity of the reaction. This is due to the formation of a specific antibody the action of which on its antigen is quantitative and probably primarily proteolytic. Anaphylaxis is a step toward immunity, which is conceived as an increased capacity for safely and rapidly eliminating the specific antigen proteid.

Theory of Antibody Formation and Action.—The current explanation of the formation and mode of action of antibodies is that given by Ehrlich's lateral-chain, side-chain, or receptor theory. This theory in its beginning was advanced to explain the assimilation of food by cells, and later applied to make clear the origin and mode of action of diphtheria antitoxin, and to furnish a reliable basis for its standardization. The theory proved so adaptable that it has been greatly amplified and extended to other related problems, such as cytolysis, precipitation, agglutination, chemotherapy. Its remarkable usefulness in promoting investigation in this field places it among the great theories of science.

Mode of Action of Toxins.—Briefly stated, Ehrlich's theory assumes that a toxin is harmful only when it is able to unite chemically with certain cellular constituents, which he calls side-chains or receptors, of proper stereochemical configuration ("as a key fits its lock"). The toxin is thus bound to the protoplasm in the same way as food-particles. If a cell does not contain suitable receptors with which a particular toxin may unite, then that toxin is quite harmless for that cell, that is, the cell is naturally immune to the toxin. In this way instances of natural immunity to toxins are readily explained; here it plainly does not concern any normal antitoxic action, but simply the absence of proper cell receptors. Sachs has shown that the red cells of the newly hatched chick are insusceptible to the action of spider toxin ("arachnolysin"); later, however, cells are formed with proper receptors, and now the toxin causes laking. In some animals immune to certain toxins the toxins may remain in the body unbound

* v. Pirquet and Schick: "Die Serumkrankheit," Vienna, 1905.

† Studies upon Anaphylaxis, with Special Reference to the Antibodies Concerned. Bull. No. 64, Hyg. Lab., U. S. Pub. Health and Mar. Hosp. Serv., Washington, 1910.

and apparently unchanged for weeks. As also indicated elsewhere, the toxin molecule is regarded as having two distinct atomic groups, namely, a haptophore (ἅπτω, to seize upon, to attack) or binding group, and a toxophore group or groups. By this conception is explained the fact that, as toxin becomes old, it may lose its toxic power, but, nevertheless, induce the production of antitoxin in suitable animals; evidently the toxophore group, being more sensitive, has been lost or changed, while the haptophore group persists and unites with the cell-receptors. Toxin so changed is called toxoid. In the case of other bodies analogous to toxins in action and hypothetic structure, the functionating group is also the more sensitive to various influences, and we now know of several "oids"—toxoids, agglutinoids, etc. It is believed, too, that in certain cases toxin may be bound by cell receptors without the action of the toxophore group being thereby necessarily set in motion; in other words, it is possible to separate, in point of time, the actions of these two groups. Thus, it has been shown that in frogs tetanus toxin is without evident toxicity below 20° C., in spite of the fact that the toxin unites to the nerve-cells below this temperature; it is the toxophore group that does not act until the temperature reaches a higher degree (Morgenroth). In further support of the reasonableness of this conception Ehrlich cites the undoubted existence of groups with definite functions in complex compounds of known chemical composition, such as the chromophoric and auxochromic groups of dyes, and the anesthesiophoric functions of the benzoyl group of cocain.

It is thought, too, that in some cases, at least, the incubation period preceding toxin action represents the period intervening between union of the haptophore group with the cellular receptor and the action of the toxophore group. In other instances it is likely that there may be more or less delay before the toxin reaches the particular cells with which it is able to unite, as illustrated by the observation that tetanus toxin, for instance, can reach nerve-cells only by way of the nerve-fibers (Meyer and Ransom).

One of the best proofs we have of the fact that toxins unite firmly with cells is furnished by the firm fixation of tetanus toxin by nerve tissue (Wassermann and Takaki); and it has been shown by Dönitz that in this combination it concerns not the white matter, but the gray matter—the neurocytes. The fixation of simple hemolysins and of hemolytic amboceptors by red corpuscles is easily demonstrable *in vitro* in the so-called absorption experiment, which is used extensively to demonstrate the specific affinity of free-cell receptors for special cells.

The Origin of Antitoxins and Other Antibodies.—It is well to state now that cellular reactions similar to those caused by toxins are also initiated by various other substances which, like toxin, are believed to unite with proper cell receptors or side-chains, after the manner of food-particles, and thus give rise to reaction products or antibodies that in every way must be regarded as analogous with antitoxins.

Substances having this power are now commonly called *antigens* (Deutsch), and toxins of various kinds, microbes, and various microbic derivatives, red corpuscles, and other cells, as well as serum, constitute or contain the most important antigens, which appear to be colloid proteins. The group of antibodies includes antitoxins, antiferments, agglutinins, precipitins, amboceptors or immune bodies, opsonins, and other substances.

The formation of antibodies is explained in this way by Ehrlich's theory: When certain special receptors of a cell are largely occupied by the haptophore groups of particular molecules,—antigens,—then there is initiated a regenerative process whereby new receptors are formed. Following Weigert's law of overcompensation in cellular regeneration, more receptors are produced than are necessary, and eventually free receptors are thrown off from the cells into the circulation. The enormous quantities of antibodies produced in immunization are not satisfactorily explained by Weigert's law, according to Pfeiffer, Wassermann, and others, who prefer to regard the reactions more as the result of direct "stimuli." Wassermann believes that in the process of receptor formation stimulation of the cells involved by the toxophore groups plays an experimentally demonstrable rôle.* The free receptors constitute the antibodies.

The importance of cell receptors in causing the formation of amboceptors is shown clearly by an experiment of von Dungern's. He established that blood-corpuscles loaded with amboceptors from digestion in heated immune hemolytic serum no longer were able to start the formation of amboceptors when injected into the proper animal. The receptors of the corpuscles being occupied, they could not unite with receptors in the cells of the animal injected, hence there was no setting free of new receptors (amboceptors). The same experiment has been repeated by Pfeiffer, with the same result, using cholera bacteria and immune serum; the amboceptor-laden bacteria were unable to immunize rabbits.

Antitoxins in the blood and other fluids are protective and curative because they unite with the haptophore group of the toxin molecules and thus prevent the latter from uniting with cells and causing morbid changes in structure and function. Toxin-antitoxin compounds are harmless and quite stable, although it has been found that the toxin may be set free again in certain cases if the union has been of brief duration (Calmette, Wassermann, Morgenroth). As stated in other words by Behring, the substances in the body that, when situated in the cells, are a primary essential for the toxic process, become curative agents when they enter the blood-stream. In general, this statement of Behring's is true. There are, however, examples of antitoxin production from the injection of toxin into naturally immune animals, and it is now believed receptors capable of uniting with toxins and forming antitoxins may occur in other tissues and organs than those on which the toxin exercises its most poisonous effect. Thus

* Proc. New York Pathological Society, 1904, iv, 77.

Metchnikoff has shown that the alligator, which is quite immune to tetanus, nevertheless produces antitoxin from injections of tetanus toxin; in this case it is believed that the toxin is bound by cells outside of the central nervous system, on which the toxophore group of the toxin can have no such effect as on nervous cells.

Receptors of simple structure, like antitoxins, which have only haptophore groups by means of which they unite with the corresponding antigens, that is toxins, and produce inert substances, are called by Ehrlich receptors of the first order. Receptors of the second order are more complicated, having a functional as well as a binding group, as illustrated by agglutinins and precipitins, which cause definite physical alterations in substances with which they unite. Receptors of the third order are represented by amboceptors which have two distinct binding groups, and serve as intermediary links between various cells and the complements, thus being the means of causing destructive changes.

THE FORMATION OF ANTIBODIES UNDER VARIOUS CONDITIONS

The Simple Antibody Curve.—By frequent measurements of the antibodies that appear in the blood after the introduction of antigen, much has been learned of the manner of antibody formation; the most important facts bearing on this point are represented in the antibody curve. The simplest curve, that obtained after a single injection of antigen in a normal animal, may be described briefly as follows: For two or three days there is, as a rule, either no change, or there may be a fall in the specific antibody, if such is already present; at the end of this period of latency, also called the negative phase, new antibody appears; at first it increases rather rapidly, and then somewhat slower, until the maximum is reached, which in most cases seems to take place about the tenth day; soon after this culmination a gradual fall begins and continues until the normal standard is reached. This is the third phase of the curve, and it may last only a few days or several weeks and even longer.

It may be well now to refer to specific instances. Ehrlich, who first recognized the peculiar double relation between antigen and antibody, was also the first to observe that acquired immunity, as measured by antibody formation, takes a wave-like course, and Brieger and Ehrlich constructed the first curve by measuring tetanus antitoxin in the milk of goats immunized with tetanus toxin. This experiment was made on previously immunized animals in the period of decline of antitoxin production, and the immediate effect of the reinjection was a fall in the antitoxin, followed by a rise on the third or fourth day, the acme being reached on the fifteenth day, whereupon a gradual decline set in. Salomonsen and Madsen found that on the subcutaneous injection of diphtheria toxin in horses antitoxin develops according to the same general plan.

On one injection of cholera vibrios in guinea-pigs new antibodies

appear in the blood on the third day, and increase rapidly until the eighth day, when a gradual fall sets in (Pfeiffer and Marx). Typical antitoxin curves have been traced after the single injections of various toxins (Madsen and Walbum, Famulener, and others), and numerous instances, many from personal observation, might be given of the wave-like rise and fall of the antibodies that develop in response to the injection of alien blood. Finally, it has been established that the antibodies, especially the agglutinins, for typhoid, colon, and dysentery bacilli, and cholera germs, after a single injection in the normal animal, of the respective antigen in various modifications, all give typical curves.* This also holds true for the pyocyaneus bacillus (Simonds and Baldauf), the glanders bacillus, and paratyphoid bacillus B. This enumeration, which makes no claim to completeness, must include, however, a general statement in regard to the opsonins. One outcome of the recent investigations of this antibody by Wright † and others is the demonstration that the course of newly produced opsonins does not differ essentially from that of other antibodies.

The Significance of the Antibody Curve.—Taking the antibody curve as a whole, it represents the rise and fall of free antibodies in the blood. To explain the rise and fall of diphtheria antitoxin Salomonsen and Madsen assumed that production and destruction of antitoxic substances take place at the same time. Assuming this to be true of antibodies in general, we may regard the curve in any part of its course as representing the balance between production and loss of antibody. On this basis it is evident that in the second part of the curve the amount of antibody being produced exceeds the amount being lost; consequently, antibody accumulates in the blood and lymph. When the acme is reached, the production and loss are equal, but production soon falls and the curve gradually sinks.

Animals, including man, normally carry in the blood small amounts of a large number of antibodies. In many instances they possess specific affinities for antigenic substances, and probably they are not essentially different either in structure or otherwise from the corresponding bodies produced on immunization. One reason for this view is that the primary fall that may occur on immunization is specific, that is, affects only the antibodies for the particular bacterium or corpuscle injected. Normally, the blood may contain vastly more antibody than necessary to neutralize the amount of antigen, which gives rise to increase of antibody. As indicated before, even when antibodies are present in large amounts, as the result of immunization, the injection of the corresponding antigen may cause a fresh output of antibodies. The primary fall often noted in the curve was first observed (Ehrlich) in animals that were reinjected during the declining phase. It may occur also when the blood normally contains antibodies for the antigen injected. Ehrlich regarded this fall as the

* Deutsch, Goldberg, Wright, Jörgensen and Madsen, Levin, Nicolls, Lüdke.
† Wright, A. E., Studies on Immunization, London, 1909.

result of neutralization by the antigen of the antibodies in the blood, but often the amount of antigen introduced seems too small to cause the fall in this way. It seems rather as if the antigen causes a temporary fall in the production of antibody, which soon is resumed at an increased rate.

The Effect of Quantity and Mode of Introduction of Antigen on Production of Antibodies.—The height and duration of the simple curve vary much, depending on the amount and kind of antigen, the place of introduction, and largely also on the individual animal. In the case of some antigens, it seems that, to a certain point, the larger the amount of antigen tolerated without serious disturbances, the greater the production of antibodies, and the longer before the normal level is reached again, but often the optimum dose, as measured by the resulting amount of free antibody, may be far less than the maximum quantity the animal can stand. Certainly the yield of antibodies does not appear to increase with the same ratio as the quantity of antigen is increased. Small quantities of bacteria and of alien corpuscles may cause a greater output of specific antibody on intravenous than on subcutaneous injection (Friedberger and Dörner), and intravenous injection of relatively small quantities of antigen is probably often the best method to study experimentally the effect of various factors on antibody formation.

In animals previously subjected to the action of a certain antigen the mechanism of antibody production may be especially sensitive to that antigen, and respond to proper doses more promptly and freely than is the case in the fresh animal. This increased sensitiveness may be the reason of the quick rise in opsonin noted by Wright and others to occur sometimes on injection of specific vaccine, and is regarded as an important factor in acquired immunity.

When successive injections of antigen are given at varying intervals, more or less complex curves are obtained. It is out of the question to consider in detail the many schemes that have been and are used to secure a maximum concentration of antibodies. In immunization with toxins and with bacteria it is the rule to begin with small and harmless quantities, and to reinject with increasing quantities, carefully graded to avoid severe reactions and prolonged depression of antibody production, at intervals of a few days, three or four or more, over a considerable period, or until the desired antibody concentration is reached in the blood.* In horses great variation exists in the power to produce diphtheria antitoxin, and sooner or later the power is lost, to be recovered, if at all, only after complete rest. Rarely an animal is discovered in which a sort of high antitoxic equilibrium is established, that continues for months without much change either on bleeding or injection of toxin (Madsen). In production of antimeningitis serum horses are injected subcutaneously

* The possibility of producing a prolonged or "cumulative" negative phase in case of established infection by too large and too frequent doses of vaccine and its dangers to the patient are emphasized by Wright.

in various parts of the body every seven days for a period of four to six months with increasing quantities of cultures and autolyzed culture-products alternately. Usually it is most advantageous to bleed animals in the course of forced immunization eight or ten days after the last injection, as the antibody concentration is likely to be high at that time.

What may take place when the antigen is injected in increasing quantities every three or four days is indicated by the agglutinin curves obtained by Jörgensen, which appear to consist of a number of superimposed simple curves of gradually increasing height up to a certain maximum; the decline which eventually set in and continued in spite of continued injections is marked by elevations of regularly decreasing height. Famulener, by increasing doses of vibriolysin and staphylolysin every second, third, or fourth day for about six injections, produced gradually rising but zigzag curves in which the maximum was attained about ten days after the last injection. On the other hand, the curves obtained by Klien* on injection every five days with increasing quantities of typhoid bacilli, and by Meakins† with increasing quantities of dysentery bacilli, staphylococci, and streptococci at more irregular intervals, show a steady rise of antibodies up to a certain point, when one antibody would fall behind while others would continue to increase, their ultimate fate not having been traced. Whether the difference between these curves and those of Jörgensen and others is dependent on differences in technic must be left unsettled. On daily subcutaneous injections of typhoid and cholera bacilli in constant doses Jörgensen obtained agglutinin curves with a somewhat prolonged latent period, the maximum being reached a few days later than after a single injection; the curve now maintained a high level for many days, and then gradually declined in spite of continuation of the injections. In dogs injected subcutaneously every day for months with the same quantity of goat blood the content of the blood in antibodies reaches a fairly high level on about the tenth day. In case small quantities (0.001 and 0.0001 c.c. of a 10 per cent. suspension per kilo of weight) are injected, the concentration at the acme is much greater than obtainable with a single dose; with larger doses (1 c.c. of 10 per cent. suspension per kilo) the concentration is not any greater than usually obtained with a single injection of that dose; in both cases a fairly constant high level may be maintained for months.

There are, then, various procedures that may secure cumulative or continued production of antibodies. With small but constant doses of antigen it may be accomplished by daily injections, at least in certain cases. With increasing doses it seems that most is attained when the injections are given at intervals of four or five days or more. It appears, however, that animals under the continuous influence of antigens eventually lose the power to produce antibodies, and that

* Bull. Johns Hopkins Hosp., 1907, xviii, 223.

† Jour. Exp. Med., 1909, xi, 100.

when different antibodies are formed at the same time, this loss of power may occur earlier for some antibodies than for others.

The Formation of Different Antibodies for the Same Cell.—The same bacterium or corpuscle may give rise to specific lysins, agglutinins, and opsonins, and probably also other specific bodies. In some cases the different bodies appear to increase in the same proportions and to describe parallel curves, *e. g.*, in dogs injected with goat blood. But in dogs injected with rat corpuscles there may be increase in the agglutinin and opsonin for these corpuscles, but not in the lysin; and after a single injection of typhoid bacilli the agglutinin does not fall at the same time as the lysin and the opsonin. Lack of parallelism has been noted also in immunization by injections of increasing doses of antigen. At first the antibodies may all increase at the same rate, the agglutinins later falling behind (Klien), or the lysins and opsonins may decrease while the agglutinins are still increasing (Meakins). This asymmetry in the curves of the antibodies educed in the same animal for the same body suggests that we are dealing with distinct substances, the production of which is dependent on similar but not wholly identical mechanisms. Furthermore, that it would not be safe in all cases to conclude that because one antibody, like the opsonin, is high or low, the other antibodies also must be high or low.

Multiple Immunization.—The influence of wholly distinct antigens on the production of the corresponding antibodies is of interest because of its bearing on mixed infections. Several writers conclude that in multiple infection production of any single agglutinin proceeds just as in single injections. On the other hand, secondary infections, especially pneumonia in typhoid fever, depress the agglutinin curve. In rabbits injected with typhoid bacilli or with rabbit septicemia Friedberger found a diminution in the production of amboceptors for cholera germs. In dogs the development of pneumonic infection may suspend almost completely the production of antibodies for alien corpuscles. Crippling of antibody formation by the introduction of different antigens may explain the gravity of certain mixed and secondary infections. The lessened resistance to streptococcus and other infections of the acute eruptive diseases, notably small-pox and scarlet fever, and of tuberculosis may depend in a measure on the inability of the body to respond freely to the stimulus of more than one antigen at a time. And the aggravation of the primary disease, *e. g.*, tuberculosis, on the occurrence of a secondary infection, may depend on depression in the manufacture of tuberculous antibodies by the antigen of the new infection. This possibility is illustrated by the suspension, in a tuberculous person, of the tuberculin reaction by an attack of measles. Here we can assume with von Pirquet * that the measles antigen suspends the production of the bodies causing the tuberculin reaction.

On the Distribution of Antibodies in Blood and Other Fluids.—In

* Verlauf der tuberkulösen Allergie bei einem Falle von Masern u. Miliartuberkulose, Wien. klin. Woch., 1908, xxi, 861.

his classic experiments on immunity through inheritance and nursing, Ehrlich demonstrated that in active immunization certain antitoxins may appear in the milk in considerable quantities. Since then other antibodies have been found in milk, and their occurrence established also in transudates and other fluids besides the blood. In a number of instances * normal antibodies have been found more concentrated in the blood than in the lymph, with traces only in the cerebrospinal and pericardial fluids and aqueous humor. The results of the estimations by Dr. Carlson and myself † show clearly that so far as the blood and lymph are concerned, the changes in the concentration of the antibodies during the course of active immunization of dogs with goat and rat blood run practically parallel, the concentration in the lymph being always somewhat lower than in the blood-serum. It is noteworthy that in dogs injected with rat blood opsonin only was demonstrable in the cerebrospinal fluid, in which it gave a typical antibody curve. In dogs transfused with the blood of actively immunized dogs the antibodies quickly reach the same relative concentration in lymph and blood as in normal and in actively immunized animals. Hence it seems that the distribution depends on the relative antibody content in blood and lymph, rather than on place of formation of antibodies, and that the rate of passage into the lymph probably is in part dependent on the concentration in the blood.

Where are Antibodies Produced?—Pfeiffer and Marx brought to light the fact that after injection of dead cholera bacteria the spleen, bone-marrow, and lymph-nodes show a definite increase of specific antibodies before any increase is detectable in the blood. A little later these tissues become less active, while the blood still steadily gains. Hence the antibodies are either formed in the blood-making organs and given off to the blood, or formed elsewhere and stored temporarily in these organs. However, as no storage in the spleen takes place in passive immunization, and as the leukocytes in actively immune animals at no time contain as much antibody as the serum, the spleen and other lymphoid structures would seem to be the actual seat of production. Wassermann obtained similar results with respect to typhoid bacilli. Certain results of splenectomy also favor this view (Deutsch). In dogs splenectomy just before and just after the injection of alien blood is followed by typical but lower curves than usual under otherwise comparable conditions. After splenectomy we would look for increased activity in the marrow and lymph-nodes, to make up in some measure for the loss of the spleen. Acute loss of blood under certain conditions increases the formation of antibodies in immunized animals, and this also points to their production in the blood-making organs. The same inference may be seen in the fact that the exposure of immunized animals to *x*-rays may prevent

* Baude and Carlson, Amer. Jour. Phys., 1908, xxi, 221. Hughes and Carlson, *ibid.*, p. 237; Becht and Greer, Jour. Infect. Dis., 1910, vii, 127.

† On the Distribution of Antibodies and their Formation by the Blood, Jour. Infect. Dis., 1910, vii, 319.

the appearance of antibodies in the blood. That acute loss of blood increases the formation of antibodies furnishes something of a rational basis for venesection, which our forefathers regarded as a most important therapeutic measure in infections.

Theoretically, any cell that can bind toxins and other antigenic substances and produce receptors may produce antibodies. Just how widely such power is spread among the cells of the body is not clearly established. On immunization by the conjunctiva or the anterior chamber specific antibodies are said to be demonstrable in the aqueous humor earlier than in the blood (Römer, von Dungern*). Wassermann and Citron claim for the cells of the pleura and peritoneum and subcutaneous tissue the power to produce antibodies for typhoid bacilli. In this connection the question as to importation of antibodies arises, and Metchnikoff ascribes the source to accumulating leukocytes. Wright and others hold that on subcutaneous injection of the antigen, antibodies, especially opsonins, are formed at the point of inoculation. The principal argument in favor of this view is that the site at which antigen is injected influences somewhat the type of reaction. While the antibody curves produced on subcutaneous, intraperitoneal, and intravascular injection of the same antigen in the same species may not always be just alike, yet it does not seem that they differ so much as to preclude altogether the idea that antibodies are not formed by one and the same set of tissues. The variations noted may all be accounted for by differences in its conditions under which the antigen enters the body at the various sites.

Whether antibodies are produced in the blood itself by the leukocytes is also a question under discussion. If antibodies were formed by and in the blood of immunized animals, it would be reasonable to look for their production in dogs freely transfused with the blood of dogs injected with an optimum amount of alien blood a short time previously. But Dr. Carlson and I have found that no production takes place under such circumstances. In recipients of blood from dogs in the second phase of antibody formation the antibody course is typical of passive immunization, as established by Madsen and others, the immediate decrease taking place rapidly and then more slowly. Our results indicate that antigen is quickly removed from the blood or in some way so changed that the antigenic property is lost. In full accord with this result is the fact that the new formation of antibodies proceeds in a typical manner in donors that are kept alive, the curve in some cases reaching a very high mark, possibly from the stimulus of the loss of blood on the blood-forming organs.

Antibody Formation in Acute Infectious Diseases.—The conception that natural recovery from infections depends largely on the immunity developed in response to the infection is supported strongly

*Leber (Experimentelle Beiträge zur Kenntniss der biologischen Vorgänge bei Tuberkulose, Zeit. f. Hyg. u. Infektionsk., 1908, lxi, 465), by means of complement fixation, obtained results indicating that in tuberculosis of the eye antituberculin appears in the humor of the infected eye long before it appears in the blood or in the humor of the normal eye.

by the observations on antibody formation in infectious diseases. In acute bacterial diseases the course of the antibodies in the typical attack resembles altogether that of the antibody curve after a single injection of antigen in a normal animal. This has been found to hold good for the pneumococco-opsonin in pneumonia,* the streptococco-opsonin in erysipelas † and scarlet fever,‡ for the diphtherio-opsonin in diphtheria,§ etc. In these diseases the opsonin is the only antibody for the bacteria in question that, under present circumstances, permits of ready measurement. The curves show definite relations to the clinical phenomena. During the early stages there is a more or less distinct fall in the specific opsonin in the blood; as the symptoms begin to subside the curve rises, suggesting that more antibody is being liberated than is neutralized by the pathogenic substances. The curve usually reaches the highest point a day or two after the acme of the symptoms, and then in many cases it falls rather abruptly. The curve is readily affected by complications, at the outset of which it usually falls. In rapidly fatal cases, *e. g.*, pneumonia, the curve may not return from the primary fall, but sink lower and lower.

The conditions appear more complicated in cholera, dysentery, and typhoid fever, in which it is possible to follow the course of at least three antibodies. In cholera Amako || reports that the opsonin, agglutinin, and lysin curves run quite parallel in the cases of mild and medium severity. The curves resemble the simple antibody curve, the negative phase being more pronounced, the acme higher, and the fall less rapid in the severe than in the mild case. In extremely severe and foudroyant cases he has found no evidence of antibody formation; in the so-called cholera-typhoid cases the negative phase was prolonged and the lysin curve rose earlier than the opsonin and agglutinin curves, this curve being the only one that he obtained in some cases. A somewhat different type of curve is given in typhoid fever, especially with respect to the agglutinin.¶ The agglutinin formation in typhoid fever in most cases begins in the first or the early part of the second week of the disease, and the maximum is usually reached in the third week. In the prolonged latency and length of time between the outset of the infection and the acme of the curve we are reminded more of the curve in animals which receive daily injections of typhoid bacilli for some time than of the curve of animals receiving but a single dose. This accords with the character of the typhoid infection, which continues more or less active for a number of days, and subsides gradually, indicating that the agglutigens and other antigens are not received in one dose, as it were, but continuously while the infection lasts. The course of the lysin and opsonin in

* Wolf, Jour. Infect. Dis., 1906, iii, p. 731; McDonald, Aberdeen University Studies, 1906, No. 21, 367; DeMarches, Lo Sperimentale, 1909, lxii, 681.

† Tunnicliff, Jour. Infect. Dis., 1908, v, 268.

‡ Tunnicliff, *ibid.*, 1907, iv, 304; Banks, Jour. Path. and Bact., 1907, xii, 113.

§ Tunnicliff, *ibid.*, 1908, v, 14.

|| Centralbl. f. Bakt., 1909, xlviii, 602; Swanschenzow, Zeitschr. f. Immunitätsf. u. exp. Therap., Ref., 1909, i, 53, found the opsonin to describe a simple curve in cholera.

¶ Jörgensen, Centralbl. f. Bakt., I, O., 1905, xxxviii, 475.

typhoid fever has not been followed so closely as that of the agglutinins, but the results obtained indicate that the course of the three bodies is essentially the same, at any rate so far as concerns the first and second phases of the curve. It has been found* that while the opsonin returns to normal in three or four weeks after complete recovery from typhoid fever, in chronic carriers it may be increased so much as to be of diagnostic value.

The Effect of Alcohol, Changes in Temperature, and Other Factors on Antibody Formation.—Unfortunately, the methods used in many of the investigations to determine the effect of certain factors on antibody formation are not satisfactory, because of the attempt to settle the outcome of the experiment by a single determination of the antibody content in the blood, the day selected usually being, it is true, that on which the simple antibody curve in the particular case was most likely to be at its height. There is individual variation in this respect, and for this and other reasons the results in some cases have been variable, and often suggestive rather than decisive. According to Trommsdorff,† severe physical exhaustion, prolonged hunger, and great chilling of the body, as well as certain other factors that are known to lower resistance, all lessen the production of antibodies in immunized animals. With respect to the effects of alcohol in rabbits, the results of Friedberger, Wirgin, and others indicate that the giving of alcohol in mildly intoxicating quantities for several days after the infection of the antigen restrains the formation of antibodies. Wirgin found that the longer after the injection before he gave the alcohol, the less its depressive effect. Friedberger and Trommsdorff's results point to a favorable influence on antibody formation by alcohol in a single mildly toxic dose at or near the time the antigen is introduced, but Wirgin's experiments go rather to the contrary effect.

Febrile processes are associated intimately with the production of antibodies, and it lies near at hand to wonder whether this production proceeds in the same way at normal and heightened temperatures. The influence of experimental hyperthermia on the formation of antibodies has been studied by Rolly and Meltzer,‡ Lüdke,§ and others. Rolly and Meltzer find that typhoid agglutinins and bacteriolysins are produced more rapidly and abundantly in rabbits that are kept overheated than in those which are kept cool. Lüdke reports similar results; he finds stimulation of the heat center by puncture to cause not merely an increase in the output of agglutinin, but also to so modify the agglutinin that an unusually firm sort of agglutination results. Torri,‖ on the other hand, who also studied the effect of puncture of the thermic center on the development of typhoid antibodies in rabbits, was unable to determine whether the hyperthermia had any effect one way or the other.

* Gaethgens, Deut. med. Woch., 1909, xxxv, 1337; Hamilton, Jour. Infect. Dis., 1910, vii, 393.

† Arch. f. Hyg., 1908, lviii, 1.

‡ Deut. Arch. f. klin. Med., 1909, xciv, 385.

§ *Ibid.*, 1909, xcv, 424.

‖ La clin. med. Ital., 1909, xlvii, 607.

Graziani * has found that of rabbits injected in the same way with filtrates of typhoid cultures, but kept at different temperatures, viz., +32°, +38°, and +2°–4° C., those kept at the low temperature developed the most agglutinin. In another experiment he kept all the animals at +32° C., bathing one-half of them in water at +20° for thirty minutes, morning and evening, and in this case the bathed animals produced more agglutinin.

The experiments I have mentioned deal mostly with the earlier phases of antibody production. The course may be influenced in the later stages also. Lüdke, being immunized with typhoid and with dysentery bacilli, found that hot baths during the stage of decline were followed by a distinct rise in the agglutinins.

ANTIBODIES IN PASSIVE IMMUNIZATION

Loos, in 1896,† was the first to demonstrate that antitoxin enters the blood of children injected with antidiphtheric serum; E. Mueller ‡ and others have found that the antitoxin disappears from the blood quite early, none being demonstrable after three weeks. Since then the time of appearance, the concentration, and the fate of the antibodies in the blood in passive immunization have been subjected to special study.

The results as to the influence of the place of introduction on the time when the maximum concentration of antibodies in the blood in passive immunization is reached may be summarized to this effect: On intravenous injection the maximum concentration is reached at once, while on subcutaneous, intramuscular, and intraperitoneal injection it is reached only after an interval variously stated at twenty-four to forty-eight or seventy-two hours.§ In man, J. Henderson Smith ‖ has found absorption of diphtheria antitoxin from the subcutaneous tissue complete only after two to three days. In the case of certain agglutinins and of diphtheria antitoxin, Levin ¶ has determined that the maximum concentration in the blood in animals is reached in about three days after subcutaneous and intramuscular injections, but during the first twenty-four hours the absorption is greater from the muscles than from the subcutaneous tissues—at the end of ten hours, 14 times greater.

Levin also has found that the introduction in animals of immune serum, no matter whether from the same or different species, and whether by intravenous, intramuscular, or subcutaneous injection,

* Centralbl. f. Bakt., 1907, xlii, 633.

† Jahrb. f. Kinderk., 1896, xlii, 360.

‡ *Ibid.*, 1897, xliv, p. 394.

§ McClintock and King (The Oral Administration of Antitoxins, Jour. Infect. Dis., 1906, vi, 46) show that if digestion is inhibited, diphtheria antitoxin is absorbed from the gastro-intestinal tract (guinea-pigs) almost as completely as after subcutaneous injection. See also Römer and Sames, Beiträge zur antitoxischen Immunisierung auf intestinalem Wege, Zeit. f. Immunitätsf. u. exp. Therapie, 1909, iv, 270.

‖ Jour. Hyg., 1907, vii, 205.

¶ Zeit. f. Immunitätsf. u. exp. Therapie, 1909, i, 3.

appears to be followed by an immediate and marked loss in antibodies for which he could offer no explanation. That is to say, the demonstrable content of antibody in the serum of the animal in all cases falls far short of the amount calculated on the basis that the antibodies are simply diluted in the blood. This deficit was greatest when the antiserum was introduced subcutaneously, less when introduced intramuscularly, and least when introduced intravenously, but even here it amounted to 40 to 60 per cent., and in some cases more. Marked individual differences occurred. It was less in the case of kindred than of alien antiserum, and especially marked when several different antibodies were introduced at the same time. On subcutaneous injection of antivibriolytic serum Tallquist noted that only about one-half as much antilysin appears to reach the blood as when it is injected into the blood. Dr. Carlson and I find that in dogs first thoroughly exsanguinated and then transfused with blood from dogs injected previously with goat blood, antibodies almost immediately begin to pass into the thoracic and neck lymph, and that they soon reach the same proportion in these fluids relative to that in the blood as in normal and in actively immunized animals. It seems then that the amount of antibody passing into the lymph, notably after intravenous injection, may go a long way toward making up the deficiency between the amount injected and the amount found in the blood.

Ehrlich observed that after passive immunization antiricin and antiabrin may remain in the blood for thirty to sixty days, depending, for one thing, on the quantity introduced. In an ass injected subcutaneously with antidiphtheric horse serum Bulloch * was able to demonstrate minute quantities of antitoxin, even at the end of one hundred days. That definite traces of antibodies could be detected so long after their introduction was received with considerable astonishment. It has since been learned that, introduced into the blood, antibodies at first are lost rapidly and then more and more slowly. Madsen † has shown that, at least in certain cases, the loss of antibody is expressible by the same formula in both active and passive immunization, kindred serum being used in the latter case.

Famulener ‡ and Levin determined that, after successive intravenous injections of antibodies (antivibriolysin, typhoid and colon agglutinin) at intervals of seven days or so, there was no difference in the rapidity of the loss—the antibodies disappeared at the same rate after each injection. This proved to be the case also when a mixture of antibodies was injected at the same time. In rabbits injected by Levin with serum of goat immunized with colon bacilli all agglutinin disappeared at the end of the same time,—four to six days,—even if the serum (of the same antibody strength) was injected in quantities ranging from 10 to 40 c.c. Consequently, it may

* Jour. Path. and Bact., 1898, v, 274.

† The Decrease of Antibodies in the Organism Indicated by a Formula. Festkrift, Statens Serum Institut, Copenhagen, 1902.

‡ Centralbl. f. Bakt., 1907, xliv, 58.

be advisable, if we wish to maintain the concentration of alien antibodies in the blood at a certain level for a longer period, to give a series of relatively small doses, rather than a single large dose.

At this point brief reference may be made to the fact that in passive immunization antibodies are retained longer if the animal is injected with antiserum obtained from its own species than if serum from alien species is used. Tizzoni and Catani, who were the first to ascribe to the origin of the serum injected importance with respect to the rate of disappearance of antibodies, found that rabbits injected with antidiphtheric serum from different species retained the antitoxin longest when it was introduced in rabbit serum. Knorr and Ransom observed that tetanus antitoxin is retained longer in passive immunization if the serum used is derived from the same species as the passively immunized animal. At the same time, as kindred antitoxin is retained the longest, Ransom found that not all alien antitoxins are lost with the same rapidity. Consequently, it is not possible to lay down a general law in regard to the fate of the antibodies of one species in the fluids of another.* Alien agglutinins and alien bacteriolysins also disappear more rapidly than the kindred—in some cases, three times as rapidly.

To account for the disappearance of antibodies from the blood of healthy animals, at least three possible mechanisms have been considered, namely, elimination in the urine and other excretions, deposition in the organs, and chemical transformation. The failure to find antibodies, except in exceedingly minute quantities, in the urine, saliva, and other excretions, and in the organs of immunized animals (Bomstein), lends favor to the view that chemical transformation plays an essential rôle in the gradual disappearance of antibodies from the blood. Certain antibodies, *e. g.*, tetanus antitoxin, pass into the milk in passively immunized animals. The suggestion has been made that antitoxin and other antibodies may induce the formation of antibodies and thus lead to the eventual defeat of the purpose of passive immunization. The possibility of formation of anti-antibodies cannot be discussed now, but it may be noted that antibodies for diphtheria antitoxin and typhoid agglutinins have not been obtained.

The fact that intravenous injection immediately gives a far greater concentration of antibody in the blood, and hence in the lymph also, than is ever attained by the gradual absorption from the subcutaneous tissue, is a strong point in favor of the direct injection into the blood of antidiphtheric serum in severe cases, as urged by Behring, Madsen, and others. The principle is, of course, equally applicable to other conditions, notably tetanus. According to Berghaus,† the curative value of antidiphtheric serum for guinea-pigs on direct injection into the blood is 500 times greater than on subcutaneous injection, and 80 to 90 times greater than on intraperitoneal injection. The one ob-

* See Römer and Sames, Ueber die Haltbarkeit heterologen Antitoxins in Organismus, Zeit. f. Immunitätsf. u. exp. Therapie, 1909, iv, 270.

† Centralbl. f. Bakt., I, O., 1909, l, 87.

jection that might be urged against the intravenous method is the possible greater danger of anaphylactic shock in susceptible persons.* Schreiber † and others have injected antidiphtheric serum intravenously in a considerable number of cases. It appears that general improvement follows sooner than on subcutaneous injection, while the local process in the throat follows about the same course in both cases. So far no dangerous symptoms have developed. In case of difficulty in entering the vein the injection may be made into the buttock, which, so far as concerns the rapidity and degree of absorption of antitoxin into the blood, is a more favorable place for injection than the subcutaneous tissue.

Outline of Practical Serum Therapy

The application of the main principles of experimental active and passive immunization referred to in the foregoing, to the actual prevention and cure of various infectious diseases in man and animals, has given rise to a variety of different procedures which may be summarized as follows:

I. PROTECTIVE

A. **Active Immunization with Infectious Organisms Only.**—(1) *Inoculation of Living, Fully Virulent Organisms.*—The principle involved here is illustrated well in the so-called variolation practised in China and other eastern countries, and introduced into England by Lady Montague in 1721. Material was taken from the pustules of small-pox patients with light attacks, dried upon threads, and inoculated into the skin of healthy persons. The resulting small-pox was milder than the natural, and accompanied with a much smaller death-rate, but the virus cannot be considered as having been attenuated, because the artificial inoculations sometimes gave rise to epidemics of severe small-pox. The comparative mildness of the inoculated small-pox has been ascribed to the circumstance that the infection was not introduced in the usual way, but through the skin, which would seem to be a less favorable point of attack. Precisely the same principle is employed today in the inoculation against sheep-pox; and here too there is the disadvantage of the possibility that the disease may be disseminated in virulent form by inoculated sheep.

Here may be mentioned Koch's discovery that the bile of animals that have died of rinderpest possesses the power, on subcutaneous inoculation of 10 c.c., to immunize normal animals to this disease. Later Kolle was able to centrifugate out and wash the virus, which then produced an infection equally as fatal as that caused by infectious blood. Hence we must conclude that bile has the power to restrain the dissemination of rinderpest virus from the subcutaneous

* According to W. H. Park (Jour. Amer. Med. Assoc., 1910, liv, 258), large doses of antitetanic serum injected intravenously within a few hours of the onset of the symptoms of tetanus have given good results.

† Münch. med. Woch., 1909, lvi, 1597.

tissue. Theobald Smith and others have found that cattle, especially young animals, may be immunized against Texas fever, a protozoan disease, by the subcutaneous or intravenous inoculation of the blood of animals that have passed through an attack a few weeks previously, and in whose blood there are only a few organisms (Piroplasma bigeminum). It is believed that in this case the lower mortality in the inoculated animals may depend upon the fact that only certain developmental forms of the parasite are introduced, whereas in the natural infection, by means of the cattle tick, other forms the result of sexual development may be concerned.

Ferran's anticholera inoculations consist in the injection, into the subcutaneous tissue of human beings, of cholera bacteria, which, when so injected, are quite harmless except for some local and general reaction, the local reaction being quite painful.

(2) *Inoculation of Living Attenuated Organisms.*—Infectious material and microbes may be attenuated in virulence in various ways, such as by passage through animals, by chemical and by physical means. The classic example of this form of protective inoculation is vaccination, described by Jenner in 1798. Here the attenuation of the still unknown virus of small-pox for human beings is accomplished by passage through cattle. It is unnecessary at this time to dwell upon other details concerning vaccination, which to this day remains an ideal form of immunization for protective purposes.

Pasteur showed that the bacterium of swine erysipelas becomes attenuated for swine by passage through rabbits, and cultures so attenuated constituted his first vaccine, while the virulence is increased for swine on passage through pigeons, and cultures from pigeons constituted his second vaccine. In this way Pasteur obtained quite satisfactory results in immunization of swine, but in practice the method has now been replaced by a combination of active and passive immunization. Haffkine's cholera prophylactic consists of vaccines (I and II) prepared according to Pasteur's general method.

The attempts at immunization by Behring, Pearson and Gilliland, Neufeld, and others of cattle against tubercle bacilli of bovine origin by means of cultures of the human bacillus (which is of low virulence for cattle) have been interpreted to mean that the human bacillus has become attenuated for cattle on account of passage through man, and also that the bacilli of human and bovine tuberculosis really are of the same species.*

Attenuation of infectious microbes by chemical means may be carried out in various ways, but at present this method is not employed in preparing materials for protective inoculation. Attenuation by physical means is illustrated by Pasteur's anthrax vaccines (cultures

* For historic summary of experiments in attenuation of tubercle bacillus for purposes of immunization, including the early work of de Schweinitz, Trudeau, and others in this country, see Salmon, Phila. Med. Jour., 1903, June 13, ii, 966.

of anthrax bacilli attenuated by growth at 42° C., and by vaccines prepared according to a similar plan for symptomatic anthrax. Attenuation by drying is an important feature of Pasteur's preventive treatment of hydrophobia (the latent period of which is so long that immunity may be produced before symptoms appear). Varying degrees of virulence of the "fixed virus" employed are secured by drying the spinal cords of rabbits that have died from inoculation with fixed virus over caustic potash at 22° C. for one, two, three days, etc.

(3) *Inoculation with Dead Micro-organisms.*—Haffkine, Wright,* Pfeiffer, and others have shown conclusively that inoculation of dead bacteria is a means of prevention of great practical importance in cholera, pest, typhoid fever, and bacillary dysentery. Actual tests have shown that high degrees of immunity and formation of antibodies are produced by the proper injection of the dead bacteria. In order to kill the bacteria, broth cultures or suspensions in salt solution of agar cultures are heated at 60° C. for about one hour. In order to hasten resorption and lessen local reaction Conradi and others have tried filtrates of autolyzed cultures. Strong's cholera prophylactic,† which is efficient experimentally, producing high bacteriolytic and agglutinating values in man as well as animals, consists of the filtered products of autolysis of killed cholera bacteria; its injection causes no local and only slight general reaction. The typhoid vaccine now being used in the United States army is prepared as follows (Russell ‡): A selected, typical typhoid strain is grown on agar in uniform tubes for eighteen or twenty hours, washed off in about 2 c.c. of physiologic salt solution for each tube, carefully heated at 60° C. for one hour; the emulsion is now diluted so that each cubic centimeter contains about 1,000,000,000 bacilli. Trikresol to the extent of 0.25 per cent. is added. Before the vaccine is used on human beings its absolute sterility is determined by cultures and inoculations of mice and guinea-pigs. The vaccine may be kept in the ice-box for months. Three doses are injected subcutaneously at intervals of ten days; the first dose contains, as a rule, 500,000,000 bacteria; the second and third, 1,000,000,000. (For results of this method of prevention see Cholera, Pest, Typhoid Fever.)

Following the recommendations of Gabritschewsky,§ inoculations of streptococci killed by heat have been practised rather extensively in Russia to prevent scarlet fever. The antiscarlatinal vaccine consists of concentrated broth cultures of streptococci, isolated from cases of scarlet fever and sterilized by heating at 60° C., 0.5 per cent. of phenol being then added. Each cubic centimeter contains 0.02–0.03 c.c. of streptococcal substance, equal, when dried, to about 0.005 c.c. In children between two and fifteen the first dose seems to be from 0.3 to 0.5 c.c.; for children between one and two years, the

* Antityphoid Inoculation, 1904.
† Jour. Infect. Dis., 1905, ii, 107.
‡ Johns Hopkins Hosp. Bull., 1910, xxi, 83.
§ Centralbl. f. Bakt., I, 1909, xli, 851.

dose is from 0.1 to 0.15 c.c.; and for adults, about 1 c.c. Three injections at intervals of about seven days are recommended, the second dose being twice and the third three times the first. The injections are given subcutaneously, either in the abdominal wall or the back.

After the first injections there may develop both local and general reactive symptoms. The local reaction rarely is described as severe, and it may be limited to a small infiltration. The general reaction varies in degree and character. The usual symptoms are a moderate fever and general depression for two or three days. In a small minority of the cases a symptom-complex results which is strikingly like that of scarlet fever, with angina, eruption, even vomiting and strawberry tongue, the course being, however, more rapid, the scarlatiniform eruption spreading over the whole body in a few hours, and passing away without desquamation (Wladimirow *). Wladimirow gives the statistics of 50,000 inoculations, and concludes that in the doses mentioned the vaccine is practically devoid of power to cause any serious harm.

According to the available reports, streptococcus inoculation is of value, and some of the authors regard it as an effective method of preventing the spread of the disease. It is claimed that in districts in which inoculation was carried out extensively a much smaller number of cases developed than in otherwise similar districts in which no inoculations were made. By means of inoculation it is believed that epidemics have been brought to a prompt ending, and that a method has been found whereby outbreaks of scarlet fever in schools and institutions can be cut short. While cases of scarlet fever do occur in inoculated children, the number of such cases in comparison with the number inoculated is exceedingly small indeed, and most of the cases are said to have developed in children that received but one injection.

Because scarlet fever varies so much in severity from time to time, and because the susceptibility of children is highly variable, great difficulties stand in the way of final determination of the real value of protective inoculation with streptococci. The results of the Russian investigators, however, appear to warrant further and well-directed efforts in this direction. Even in case the scarlet fever is not caused by streptococci, the inoculations may serve to increase the resistance to complicating streptococcus infections, and in that way lessen greatly the danger of the disease.

Weaver and Tunnicliff † have shown by experiment that streptococci killed in galactose solution (25 per cent.) have a greater immunizing power, and are not at all any more toxic than streptococci killed by heat, if as much. The galactose streptococcus vaccine is made as follows: The cocci are grown on blood-agar slants in the incubator for twenty-four hours, when the fluid of condensation is removed and the cocci taken up in a small quantity of 25 per cent. galactose solu-

* Abstr., Zeit. f. Immunitätsf. u. exp. Therapie, ref., 1909, i, 258.
† Jour. Infect. Dis., 1908, v, 589.

tion. This suspension is placed in the incubator for forty-eight to seventy-two hours; it should be shaken several times in the interval. Usually the cocci are killed at the end of twenty-four hours. To determine the question of sterility, cultures must be made. In the further preparation the suspension is distributed in suitable amounts in small tubes and thoroughly centrifugated; the fluid is then removed, and the sediment rapidly desiccated in vacuum over calcium chlorid; the tubes may now be sealed and stored in the ice-box. Just before the injection the dried residue is dissolved in sterile salt solution. For protective inoculation of children three injections are recommended at intervals of seven days, the first dose to contain 250,000,000, the second, 500,000,000, and the third, 700,000,000 killed streptococci.

B. **Active and Passive Immunization Combined (Serovaccination).** (1) *Living, Fully Virulent Bacteria Combined with Potent Specific Serum.*—Lorenz immunizes animals against hog cholera by giving them, first, specific serum, and later virulent hog-cholera bacilli. In the case of rinderpest, this combined method is carried out as follows: Serum (10 to 20 c.c.) of highly immunized cattle is injected subcutaneously on one side, and 1 c.c. of virulent rinderpest blood on the other. A mild attack follows, which terminates usually in recovery and immunity. During the attack the blood is highly infectious. The serum hinders the as yet unknown virus from attacking vital organs. Animals may be rendered immune to foot-and-mouth disease in the same general way.

(2) *Attenuated Living Organisms Combined with Serum.*—This method is used with excellent results against anthrax by Sobernheim. Kolle and Otto have been able to protect guinea-pigs from fatal doses of the pest bacilli by means of immune horse-serum and attenuated cultures of pest bacilli.

(3) *Dead Bacteria and the Corresponding Serum.*—This method has been proposed by Besredka * for pest, cholera, and typhoid.

C. **Passive Immunization.**—This consists in the injection of antitoxic and anti-infectious serums for prophylactic purposes; the doses and results are discussed in connection with diphtheria, tetanus, pest, epidemic meningitis, and other diseases.

II. CURATIVE

A. **Active Immunization—Vaccine Therapy.**—The first to practise injections of a bacterial product for curative purposes in established infection was Koch, when he introduced tuberculin as a remedy for tuberculosis. Petruschky and Richardson each independently attempted to hasten the reactions that lead to recovery in typhoid fever by the injection of sterile products of typhoid bacilli. To Sir A. E. Wright, however, belongs the credit of introducing vaccine therapy. Vaccine therapy, that is, inoculation of dead bacteria for therapeutic purposes, rests on the following considerations: (1) The belief that

* Ann. de l'Institut Pasteur, 1902, xvi, 918.

recovery from infection in a large measure depends on the antibodies developed by the body in response to the infection; (2) the belief that, under certain conditions of infection, the body fails to develop antibodies in adequate fashion; (3) the belief that the suitable injection of dead bacteria or bacterial substances, of exactly the same kind as cause the particular infection, stimulates the formation of specific antibodies and thus promotes healing. The essential prerequisites for therapeutic inoculation are: (1) Correct etiologic diagnosis; (2) the use of sterilized pure cultures or vaccine of the bacterium causing the infection, or sterile products of such bacterium; (3) the injection of proper doses at proper intervals so as not to lower, but to raise, the active antibacterial powers of the body. As guide to proper dosage in the individual case and to the proper interspacing of the injections, Sir A. E. Wright, in conjunction with Douglas, and on the basis of a method already used by Leishman, devised his highly ingenious method of determination of the specific opsonic index of the blood-serum of the patient, the opsonin which Wright and Douglas discovered being the only antibody readily available for measurement in most of the infections in question. It has been found that when certain optimum quantities of killed bacteria are injected in patients with chronic and subacute infections, there may result first a fall in the index, that is, in the amount of specific opsonin, lasting a day or two, followed by a definite rise, the index describing a curve which, in its outline, corresponds well to the simple antibody curve, the previous level being approached again after a few days. In such cases there is very often coincident improvement. If larger quantities of vaccine are injected, the fall may be more pronounced and prolonged and associated with exacerbation rather than improvement in the symptoms, especially if reinjection is practised while the index is still depressed. Owing to an increased sensitiveness of the infected body to the infecting, hence immunizing, substances, maximum positive responses may be obtained with small quantities of vaccine or antigen. The consensus of opinion at the present time appears to be that the clinical symptoms constitute a sufficient guide to vaccine therapy in the hands of careful observers thoroughly familiar with the general principles briefly outlined in the foregoing. The best results are secured with doses so small that no immediate systemic reactions develop recognizable by the usual clinical means. Experience also indicates that, as a general rule, the best results are obtained with vaccine prepared from the bacterial strain actually causing the particular infection, that is, with homologous or autogenous rather than with stock vaccines. Speaking generally, the vaccines are prepared by heating suspensions in salt solution of the bacteria from fresh and pure growths on the usual media to 60° C. for about one hour, or at a somewhat lower temperature for a little longer time. Before using, the sterility of the vaccine must be determined by cultural methods. For safety's sake a small amount of some preservative, such as lysol or carbolic acid,—0.5 per cent.—is often mixed with the vaccine.

The amount to be injected is fixed by the number of bacteria present, as determined by actual count by means of the method devised by Wright for that purpose. The following table gives the amounts commonly employed, the smaller being the initial doses:

Bacteria.			
Staphylococcus	25,000,000	to	1,000,000,000
Streptococcus	5,000,000	"	500,000,000
Gonococcus	1,000,000	"	200,000,000
Pneumococcus	1,000,000	"	300,000,000
M. catarrhalis	1,000,000	"	300,000,000
B. coli	2,000,000	"	1,000,000,000
B. pyocyaneus	2,000,000	"	1,000,000,000
B. of Friedländer	4,000,000	"	8,000,000
B. typhosus	5,000,000		

In tuberculosis some form of tuberculin is used, most frequently, I believe, the tuberculin R. or tuberculin B. E., of which the initial dose for children is $\frac{1}{100,000}$ mg.; for adults, $\frac{1}{50,000}$ mg.*

In chronic and subacute streptococcus infections the galactose-killed streptococci, the method of preparation of which, by Weaver and Tunnicliff, has already been described (p. 275), appear to possess certain advantages over the heat-killed.

Recently, Rosenow has prepared a pneumococcus vaccine from virulent pneumococci, which are freed by autolysis and centrifugalization from the substance on which virulence depends,—"virulin,"—thus increasing, it is believed, the antigenic powers of the cocci.

The present status and methods of employment of vaccine therapy of the various infections are described elsewhere in connection with their general treatment.

SERUM THERAPY OF SUNDRY CONDITIONS

The problems and present status of the serum therapy of anthrax, of pyocyaneus, staphylococcic, streptococcic, and pneumococcic infections, and of snake-poisoning present many phases of interest and instruction in the light of the preceding discussion. The consideration of certain aspects of the serum therapy of these conditions may be introduced conveniently at this point without disturbance of the general plan of this handbook.

Serum Therapy of Anthrax.—*Natural Immunity.*—The bacillus of anthrax is virulent for sheep, cattle, horses, and other animals, including man, but rats, dogs, many birds, and cold-blooded animals present a high degree of immunity to this bacillus. The causes of this immunity are not yet clearly understood. It is evident, however, that the mechanisms whereby anthrax bacilli are destroyed in animals naturally immune may differ in different species. In the case of adult white rats, for example, the serum is highly anthracidal, due, according to Behring and others, to alkalinity, but from experiments made by Horton this action is more likely due to a special, thermostable

* See New and Non-official Remedies, 1910.

substance, which is destroyed by heating the serum at 80° C. for thirty minutes, and that without any change in the alkalinity of the serum. At birth the serum loses its anthracidal power at 56° C., the thermal resistance rising as the animals grow older. Whether the anthracidal power of rat serum is due to the interaction of an unusually thermostable complement and amboceptor, in accord with the usual scheme of bacteriolysis, has not been determined.

In dogs and fowls, on the contrary, the serum is not anthracidal. Bail and Petterson have shown that the serums of these animals do contain amboceptors that are taken up by anthrax bacilli, but bacteriolysis cannot be completed, because the serums do not contain the proper complement. Rabbit serum, however, contains suitable complement, so that in the presence of dog serum or chicken serum, in themselves harmless, minute quantities of rabbit serum, so small as to have no appreciable anthracidal action, may cause extensive destruction of anthrax bacilli. While dog serum is a good medium for anthrax bacilli, defibrinated dog blood is anthracidal. Analysis of this action shows that it depends on the conjoint effect of the plasma and polymorphonuclear leukocytes, and is associated definitely and constantly with phagocytosis, which must be regarded an essential step in the process of destruction.

These references serve to indicate that natural immunity to anthrax cannot be explained either by phagocytosis or by bacteriolysis exclusively. Each species seems to be more or less a law unto itself. Caution must be used also in the application of experimental results *in vitro* to the explanation of the more complex conditions *in vivo*. The susceptibility of the rabbit to anthrax seems rather paradoxic, in view of the strongly anthracidal action of rabbit serum. Bail and Petterson found, however, that the anthracidal power is neutralized by suspensions of the internal organs of the rabbit, which indicates that in life the plasma may be restrained from exercising its anthracidal power. It is possible, too, that in some species, like the rabbit, the destruction of organisms, such as anthrax bacilli, may set free substances that neutralize normal bacteriolysins.

Artificial Acquired Immunity.—Active Immunization.—Various methods have been used to establish active immunity to anthrax, the most important and most successful being the injection of attenuated cultures (Pasteur's antianthrax vaccination, 1881). Pasteur's method consists of the use of two vaccines or attenuated cultures of anthrax bacilli, namely vaccine I, the weaker, which is prepared by growing bacilli at a temperature of 42.5° C. for twenty-four days, and vaccine II, which is made in the same way, except that the growth is continued for twelve days. Pasteur showed, by his remarkable demonstration at Pouilly-le-Fort, in May, 1881, that susceptible animals, such as sheep, may be successfully immunized by means of these attenuated cultures. The importance of animal species in active immunization is shown by the fact that it is impossible or exceedingly difficult to immunize rabbits and guinea-pigs in this way.

Sobernheim has observed that cattle may resist fatal doses after having received injections of minute quantities of virulent bacilli ($\frac{1}{1000}$ of a loopful), but this method is of scientific rather than practical interest.

It seems questionable whether real immunity to anthrax has ever been produced by means of sterilized bacterial products or sterile materials from infected animals. The results of the various experiments in this line are contradictory, and it is likely that the increased resistance sometimes noted after injection with the sterile products may have been of a non-specific character. Further progress in this line appears to await the demonstration of a specific and active anthrax poison. So far all substances of intracellular or extracellular character derived from anthrax bacilli have been devoid of specific toxic action.

Active Immunization by Pasteur's Method as the Means of Practical Prevention of Anthrax.—Broth cultures of the vaccines are used, vaccine I being injected twelve to fourteen days before vaccine II. The usual dose of each is 0.25 c.c. for cattle and 0.125 c.c. for sheep. The method is used also for horses, goats, and swine. The vaccines remain active only about seven days. The first vaccine produces little or no reaction; it, however, increases resistance, so that the animal can withstand the second vaccine, which causes marked reaction and is the actual immunizing agent. At present the actual losses traceable directly to the vaccination are generally stated to be 1 per cent. in the case of cattle and a little more in sheep. In spite of early skepticism, especially on the part of German scientists, Pasteur's method has grown in use in numerous European and South American countries. Its use has lowered the mortality from anthrax in countries where it was endemic from 10 per cent. to about 0.5 per cent. At the same time the incidence of anthrax in man in these countries has been lowered. The duration of the protection is generally assumed to be about one year.

Passive Immunization.—The serum of naturally immune animals—dog, frog, rat, chicken—has been found to have no protective action against anthrax in susceptible animals, the early claims of Ogata and Jasuhara to the contrary notwithstanding.

In 1895 Sclavo and Marchoux, independently, showed that the serum of thoroughly immunized animals (asses, goats) may not only protect rabbits against anthrax, but cure animals with established infections, and it has been found that immune anthrax serum may exercise protective as well as curative powers upon anthrax infection in sheep and cattle (Sobernheim, Sclavo, Mendez). Sclavo found that the intravenous injection of a small amount of an active serum saved animals in which bacilli had entered the general circulation. All observers agree that a specific anti-anthrax serum of high value is obtainable only from animals in which have been produced a high degree of active immunity. For this purpose sheep, asses (Sclavo), dogs, and horses appear the most serviceable. The animals are pre-

pared for the injection of virulent bacilli by means of Pasteur's method, or some modification of it. As soon as they are able to withstand bacilli of full virulence the immunization may be pushed, and in two to three months it is usually possible to inject large masses of bacilli every ten to fourteen days. The blood is best drawn two to three weeks after the last injection. The serum is said to keep for years. The accurate testing of the serum presents certain difficulties. It is accomplished accurately enough for practical purposes, however, by determining the amount of serum that, on intravenous injection, saves rabbits from $\frac{1}{1000}$ of a loopful of virulent bacilli injected subcutaneously. A serum that protects rabbits in this way in doses of from 1 to 6 c.c. is regarded as powerful.

The Action of Anthrax Serum.—Inasmuch as anthrax is a bacteremic disease in which intoxication is not of such prominence as in diphtheria, for instance, it would seem reasonable to assume that the protective and curative powers of anti-anthrax serum are due to its anthracidal action. But the serum of normal and immunized animals appears to act similarly in this respect. Thus, normal dog serum is not anthracidal, neither is immune dog serum. Again, the serum of immunized sheep, cattle, and horses is not any more bactericidal for anthrax bacilli than the serum of normal animals. Werigo and Marchoux believe they have observed that phagocytosis is more active in immune than in normal animals, but Sobernheim was not able to convince himself that such was the case in his experiments. This phase of the problem merits reinvestigation in the light of our newer knowledge concerning the mechanisms of phagocytosis. It has been found that in highly immunized animals anthrax bacilli and spores may remain alive for days and even weeks at the site where injected. Hence it has been thought that anthrax serum prevents the entrance of bacilli into the circulation. Cases have been observed, however, in which the blood of highly immunized animals swarmed with bacilli eight to twelve days after injection.

The Practical Use of Anthrax Serum.—Anthrax serum is of use as a protective for horses, cattle, and sheep, especially when it is desirable to establish a passive immunity, though of limited duration, as rapidly as possible. Subcutaneously injected, 20 to 25 c.c. protect the animals for several weeks. The serum is also curative. Advanced cases of anthrax may be cured by its use. For curative purposes the doses vary with different serums: 20 to 30 c.c. subcutaneously or extravenously, repeated daily, is the usual dose in cattle.

Serum therapy of human anthrax (carbuncle) was introduced at the same time by Sclavo, in Italy, and Mendez, in South America. Sclavo injects 30 to 40 c.c., divided between three or four places, and repeats this in twenty-four hours if necessary. Mendez uses a serum of which 3 c.c. is the dose for curative purposes in man. The treatment has given excellent results and is warmly recommended by clinicians.* In Italy the mortality of the injected cases was 6.09 per

* Legge, Lancet, March 25, 1905.

cent. according to Sclavo, whereas the earlier death-rate from anthrax was 24.16 per cent.

Combined Active and Passive Immunity (*Serovaccination*).—The transitory character of the passive immunity produced by anthrax serum led Sobernheim to try the combined use of serum and attenuated cultures. This has given satisfactory results, especially in South America, where the method has been used extensively. Completely harmless, the method results in immunity lasting about one year. The serum is injected in one place (cattle and horses, 5 c.c., sheep, 4 c.c.) and the culture in another. Only one treatment is necessary.

Serum Therapy of Streptococcus Infection.—*Active Immunity to Streptococci in Man and Animals.*—There is little evidence of a clinical character to show that any pronounced immunity follows the ordinary streptococcus infections in man. The most important streptococcus infection in the horse, namely, the disease known as strangles (Streptococcus equi, Schultz, 1888), is regarded as productive of an immunity lasting from one to two years.

Experimental immunization of various animals, especially rabbits, may be accomplished successfully by various methods, as shown first by Behring in 1892. The antistreptococcus serums of commerce are obtained mostly from immunized horses. Denys and Leclef, in 1895, immunized rabbits by injecting them with small but gradually increasing doses of a virulent streptococcus. In this way they succeeded in establishing an immunity to about 1000 times the fatal dose of this organism for normal animals. About this time Roger, Marmorek, and others immunized horses and mules with streptococci, and in each case there was obtained an antiserum with some protective powers against the particular strain of streptococcus employed. More recently immunization has been begun with small quantities of a not highly virulent strain, or with killed streptococci, so that local and general reactions of only moderate severity are produced. After the subsidence of all symptoms a somewhat larger quantity is injected, and eventually it becomes possible to inject virulent material in increasing doses.

Filtrates of streptococcus cultures are of little use in immunization, because they do not appear to contain an adequate amount of specific substances. Whatever streptococcus poisons there are appear to be closely bound to the bacterial cells, because streptococcal filtrates, even of highly virulent strains, possess but little toxicity. Virulent streptococci are especially characterized, perhaps not so much by toxicity as by a high degree of resistance to the streptococcidal forces of this organism (Denys, v. Lingelsheim). They produce a hemolysin (streptolysin) that has been studied by Besredka, and which G. F. Ruediger* has showed possesses a haptophore and a toxophore group (the haptophore group may be neutralized by chicken serum, the toxophore group is destroyed by zinc chlorid). Strepto-

* Jour. Amer. Med. Assoc., 1903, xli, p. 962.

cocci also produce leukocidal substances, about which we know but little.

Antistreptococcus Serums.—At present antistreptococcus serums are prepared according to different plans: In one, the earlier, the streptococci used for immunization, which are obtained from human streptococcus lesions, are first made highly virulent for animals, such as rabbits and mice, by repeated passage through these animals. Marmorek's first serum was the result of immunization with a streptococcus from a pseudomembranous angina, and made so virulent by passage that it was thought a single streptococcus would prove fatal for rabbits. Denys believed that it would be of advantage to immunize with several virulent strains, as the reactive products might differ. Aronson's serum was first obtained from horses treated with a streptococcus from a case of scarlatinal angina, and made virulent for animals by passage through mice. This serum may be strongly protective (0.5 c.c. protecting against 100,000 times the fatal dose), as well as curative, in mice.

Later, both animal-virulent strains and strains isolated directly from human beings have been used for immunization, a plan also followed by Besredka and others. According to another plan, introduced by Tavel, the streptococci are used just as they come from the human body, and without any effort to give them virulence for animals. Tavel's own serum is the result of the immunization of horses with several cultures of streptococci obtained from human beings and not subjected to animal passage. Moser's so-called antiscarlatinal serum is prepared according to Tavel's principle, but the streptococci are obtained postmortem from the heart's blood of subjects dead of scarlet fever. Menzer's serum is also polyvalent, being prepared with unchanged streptococcal strains of human origin, especially from the lesions of rheumatism. Recently Meyer and Ruppel have proceeded as follows: First the horse is immunized with a strain made virulent for animals; then it is immunized with a strain that is found to be virulent for animals immediately on its isolation from the human lesions (the virulence of such strains may be preserved for a long time in defibrinated human blood); this immunization is continued until small quantities (0.01–0.005) of the serum protect against the second strain; finally, the serums of several horses treated in this way, but each with a distinct, original, human strain, are mixed into a polyvalent serum. In this way it is hoped to furnish antibodies for the largest number of different strains of streptococci.

Only the serums obtained by immunization with streptococci virulent for animals can be tested by the aid of animals. As indicated, such serums may protect animals against many times the minimal fatal dose of the particular strain or strains used for immunization, and possibly also others. From experiment, however, we can learn but very little concerning the action of these serums on streptococci that are obtained directly from human infections and that are devoid of

virulence for animals, the quality of animal virulence in such cases being acquired only by repeated passage through animals.

The serums obtained by immunization with streptococci derived directly from human sources, as a rule, have little or no effect on animals infected with virulent streptococci. Consequently, we have no physiologic method of obtaining knowledge of the presence or absence of specific antibodies in these serums, and lack in large measure the necessary means to test properly the effects of antistreptococcus serum on the streptococci engaged in human infections. This leaves us without adequate control of the eventual antistreptococcal strength of the serums offered for use. Undoubtedly, useless serums are offered for sale. To determine the clinical effects of antistreptococcus serums is, of course, exceedingly difficult, in view of the erratic course, the varying severity, the absence of epidemics, and the difficulties of diagnosis of pure streptococcus infections. The empirical results obtained from the use of antistreptococcic serum in various diseases are discussed in other parts of this work (scarlet fever, small-pox, puerperal infections, etc.). The preparation of antistreptococcic serum is, consequently, as yet in the experimental stage and merits continued efforts.

Mode of Action of Antistreptococcus Serum Produced with Streptococci Virulent to Animals.—I have stated that the serum of animals immunized with virulent streptococci has more or less well-marked protective power against experimental streptococcic infections. The mechanism of this protection has been made the subject of special investigation by Denys and Leclef, Bordet, Besredka, Neufeld and Rimpau, and others. Antistreptococcus serum is not bacteriolytic, because it has been shown repeatedly that streptococci multiply in it with great rapidity,—non-virulent less so than virulent,—and it is not possible to complement it with normal serum. Neither have we any evidence that it is antitoxic in its action. Streptococcus serum may contain antistreptolytic substances, but it is doubtful if these substances in most serums are present in any greater quantities than in normal horse serum (G. F. Ruediger). Besides, streptolysin, though probably of considerable significance, cannot be regarded as the essential pathologic factor in streptococcus infections. It consequently is necessary to seek some other explanation for the protective action of antistreptococcus serum.

Several years ago Denys and his pupils, in the course of an investigation into the mechanism of streptococcus infection, made the important observation that normal rabbit leukocytes take up the non-virulent strain of a streptococcus, whereas the strain of the same organism, made virulent by successive passage through rabbits, is not taken up by the phagocytes. Marchand has concluded that this depends on some physical condition of the virulent streptococci, for the following reasons: Neither living nor dead virulent cocci are taken up; furthermore, there is no phagocytosis of virulent cocci freed by washing from excretory products and placed in filtrates of the non-virulent strain, whereas non-virulent cocci, placed in filtrates of the

virulent, are taken in freely. On this account the Louvain investigators define a virulent streptococcus as one that, for some undetermined physical reason, is insusceptible to phagocytosis. In the serum of immunized rabbits and horses, however, the leukocytes possess marked phagocytic power on virulent streptococci, a power which Denys and Leclef have ascribed to the action of the serum on substances in the cocci that in some way prevent phagocytosis.

Bordet and Besredka conclude that potent antistreptococcus serum stimulates the phagocytes, because of the greatly increased local polynucleosis and phagocytosis, in the presence of immune serum as compared with normal serum. But it is exceedingly doubtful whether this is the complete explanation. The observers mentioned did not consider the possibility that the serum may directly influence the bacteria. Neufeld and Rimpau * have found that the treatment of leukocytes with antistreptococcus serum does not enable them to take up virulent streptococci when suspended in the normal serum. But treatment of virulent streptococci with immune serum, then washing in NaCl solution, and adding them to a suspension of leukocytes in normal serum, gives good phagocytosis. This experiment, which Dr. Ruediger and I have repeated with the same result, shows that the immune serum acts on the virulent cocci, and in some manner changes them in such a way that the leukocytes can take them up.

The demonstration that antistreptococcus serum causes phagocytosis of virulent streptococci, however, does not prove that the serum owes its protective action to this effect. For one thing, it must be shown that virulent streptococci are destroyed within or by the phagocytes, that phagocytosis is an essential step in the destruction of streptococci. This has been done *in vitro* by Denys, who found that in mixtures of normal rabbit leukocytes, normal rabbit serum, and virulent streptococci there was little or no reduction of bacteria, but if immune serum was added in place of the normal, then an active phagocytosis ensued, with complete destruction of the cocci. In the peritoneal exudate of mice, examined at short intervals, one finds marked phagocytosis in the animals injected with virulent streptococci plus antiserum, while in the controls there is little or no phagocytosis and rapid increase in the number of cocci.

Serum Therapy of Staphylococcus Infection.—Pathogenic staphylococci present many points of interest in connection with serum therapy. Mention has been made already of the fact that Richet and Hericourt succeeded in protecting rabbits against staphylococcus infection by means of the defibrinated blood of a dog that had been injected with staphylococci. This is generally regarded as the first attempt at prophylaxis with immune serum. Since then we have learned that the mechanism of staphylococcus infection is a complicated one, in which are concerned true toxins, staphylolysin and leukocidin, as well as pyogenic bacterioproteins, and possibly also endotoxins. A potent antistaphylococcic serum consequently should

* Deut. med. Woch., 1904, xxx, 1458.

contain a variety of antibodies, antitoxic as well as antibacterial in nature.

It has been shown that the serum of patients that recover from staphylococcus infections contains substances that protect rabbits against subsequent injections with fatal quantities of staphylococci (Canon and Peterson). Active immune serums with protective powers have been obtained also from goats and horses, immunized in various ways, but so far none of these serums has been powerful enough to cure established infections. Capman and Bulloch have pointed out that the serum of animals injected with increasing quantities of staphylococci may have toxic properties. There is evidence that active antistaphylococcus serum owes its power, at least in part, to immune opsonins. The investigations of Wright and others show that in chronic staphylococcus infections treated with proper vaccine the opsonin content of the blood may be increased.

Antileukocidin.—Denys and van der Velde showed that, by subcutaneous injections of rabbits with pleural exudate containing leukocidin, the staphylococcic poison that kills leukocytes (van der Velde), an antileukocidin could be obtained. Heating the leukocidin to 60° C. for thirty minutes deprives it of this immunizing power. Later, Neisser and Wechsberg obtained antileukocidin by injecting goats and rabbits with filtrates of old staphylococcus cultures in broth. They also found that all staphylococci elaborate the same leukocidin. Many normal serums, including human, contain antileukocidin in relatively small quantities.

Antistaphylolysin.—Staphylococci also produce a hemolysin,—staphylolysin,—a true toxin, for which the serum of many animals contain an antibody. In the case of man the quantity varies much in different individuals. An artificial antistaphylolysin is obtained by subcutaneous injections of staphylolysin. It also develops rapidly in staphylococcic infections, and it has been proposed * to use this antilysin in the diagnosis of obscure staphylococcic diseases. The authors quoted determined that, in the case of normal serum, 0.1 c.c. is, as a rule, sufficient to neutralize 0.05 c.c. of staphylococcus filtrate, which quantity contains, on an average, sufficient lysin to lake one drop of fresh rabbit blood. In 19 of 25 serums from patients with definite staphylococcic infection the antilytic power was increased from 10 to 100 times that of normal serum. In the remaining 6 cases the authors found considerable increase in antilytic power, but they think that the relative low degree of increase was due to the recent date of the infections. It seems that the antilysin develops gradually, and the reactive faculty of various persons may vary considerably. So far as known now, this antistaphylolytic action is specific.

This brief review indicates that much has been done toward a basis for the production of an active and safe antistaphylococcus serum, for which there is need in view of the gravity of various staphylococcic infections.

* Bruck, Michaelis and Schultze, Zeit. f. Hyg. u. Infektionsk., 1905, l, 144.

Serum Therapy of Pneumococcus Infection.—*Acquired Immunity.*—We know that repeated attacks of lobar pneumonia occur in the same individual at frequent intervals; furthermore, that various pneumococcal infections frequently occur in the wake of pneumonia. The immunity following pneumonia is consequently, at all events, feeble and brief, as compared with that following the acute exanthemata, cholera, and typhoid fever. Nevertheless, some immunization does take place because the serum of convalescents from pneumonia may render rabbits and mice more or less refractory to pneumococci; and the profound changes at the pneumonic crisis, when the infected body, so to speak, sterilizes itself, are associated with the development of opsonin and probably other antibodies as well (Wolf and MacDonald).

In 1886 A. Fraenkel demonstrated that rabbits may be actively immunized to fatal doses of pneumococci. This was followed by varied attempts at immunization, but the results obtained were often contradictory. Small quantities of virulent organisms, attenuated cultures, exudates, and sputum containing pneumococci, filtrates of pneumococcal cultures, and purified substances purporting to contain "pneumotoxin," were all used in various ways and with more or less apparent success.

That animals may be immunized was established, however, and efforts were made to protect against pneumococci, and even to heal established infections by the serum of immunized animals (Foa and Carbone, Emmerich and Fawitzky, F. and G. Klemperer). Foa and his coworkers used the serum of animals immunized with sterilized cultures, and F. and G. Klemperer employed the serum or tissue juices of animals immunized with cultural filtrates which they believed to contain "pneumotoxin." Washbourn, Mennes, Pane, and others used larger animals for immunization, and serum with definite protective properties for rabbits and mice has been obtained; thus, 0.75 c.c. of Pane's ass serum, which has been used extensively in Italy, and is obtained by immunization with a strongly virulent culture (0.1 c.c. of a 10,000-fold dilution killed rabbits in two days on intravenous inoculation), protects rabbits against 20 times the fatal dose. The use of antipneumococcus serum has given uncertain results so far; the same is also true of the serum of convalescents from pneumonia. (See Treatment of Pneumonia.) Römer has made extensive experiments in the treatment of ulcus serpens of the cornea with antipneumococcic serum obtained from horses injected with highly virulent strains, and claims serum with therapeutic effect on corneal pneumococcus infection may be obtained. In the antipneumococcus serums on the market in this country a year ago it was impossible to demonstrate antibodies for pneumococcus by any methods usually used for that purpose.

The Nature of Acquired Immunity to Pneumococcus.—F. and G. Klemperer believed, on insufficient grounds, that antipneumococcic immunity was antitoxic in its nature. Bonome and others have as-

cribed the effect of immune serum to bacteriolytic action, but in my opinion without adequate basis, because there is but little evidence that immune pneumococcus serum is bacteriolytic to pneumococci in the ordinary sense of the word. Thus, Römer is forced to assume that the serum is activated by something in the living body only. Rosenow * has shown conclusively that fresh normal and pneumonic serum is without any pneumococcidal effect.

Certain facts speak strongly in favor of phagocytosis playing an important rôle in pneumococcus immunity. Thus, Issaeff observed that the serum of animals immunized to pneumococci was neither antitoxic nor pneumococcidal, but appeared to stimulate the leukocytes to an intense phagocytosis. Pane also was led to believe that immune serum stimulates the leukocytes. Mennes' experiments are very interesting.† By repeated passage through animals he increased the virulence of his pneumococci so that $\frac{1}{100,000,000}$ c.c. of the blood of the infected rabbit killed another rabbit in twenty-four hours, but the toxicity of the cultures of such highly virulent pneumococci showed no correspondence to their virulence. Rabbits were immunized against pneumococci by repeated, slowly increasing quantities of either culture fluids or living cultures. This immunity was dependent on a change in the serum, which manifests itself in a marked and rapid phagocytosis, as seen on the warm stage when the serum was mixed with leukocytes either from normal or immune animals, the leukocytes alone not acquiring any new or specific powers. The serum alone of immunized animals did not have any pneumococcidal qualities, as shown by the plate method, but when mixed with either normal or immune rabbit leukocytes, well-marked destruction of pneumococci took place. He also found that in the serum of immune animals mixed with pneumococci the leukocytes lived much longer than in the serum of normal animals, an observation that suggests that immune serum neutralizes certain leukocidal effects of pneumococci. Inoculated goats, rabbits, and horses gave a serum of this kind, and Mennes found that, by prolonged immunization, horses gave a serum with preventive and curative powers.

It seems clear that the effects of the immune serum described so clearly by Mennes depended on the presence of immune opsonins. More recent experiments by Neufeld point in the same direction. At all events, both serum and leukocytes were necessary for destruction of pneumococci in Mennes' experiments, as also in Rosenow's extensive experiments with human leukocytes and serum both from healthy persons and patients with pneumonia and pneumococcus endocarditis. The importance the leukocytes hereby seem to acquire is in full harmony with the accepted prognostic significance of leukocytosis in pneumonia and pneumococcemia. In cases of chronic pneumococcus endocarditis Rosenow has found that the destructive power of the

* Jour. Infect. Dis., 1904, i, 280.
† Zeit. f. Hyg. u. Infektionsk., 1897, xxv, 414.

leukocytes may be diminished, due at least in part to changes in the serum of such cases.*

Serum Therapy of Pyocyaneus Infection.—Bacillus pyocyaneus is one of the few bacteria that produce a soluble toxin. After Charrin had demonstrated that animals may be immunized actively with Bacillus pyocyaneus, Wassermann showed that immunization with living cultures gives rise to a bactericidal serum, while immunization with dead broth cultures gives rise to a serum at once antitoxic and bactericidal. Wassermann used goats for this purpose, beginning with small doses (half of the quantity ordinarily fatal to guinea-pigs), and slowly increasing until 100 times that amount was injected. From 0.3 to 0.5 c.c. of this serum neutralized 10 times the fatal dose for guinea-pigs. The serum of goats so immunized also contained specific bactericidal substances, so that it protected guinea-pigs against living bacilli as well. Under the influence of immune serum pyocyaneus bacilli are destroyed in the peritoneal cavity of guinea-pigs (Pfeiffer's phenomenon), but with less rapidity than typhoid and cholera germs are destroyed by their respective immune serums.

Wassermann has obtained serum so powerful that 1 milligram sufficed to protect a guinea-pig against one loopful of living, virulent pyocyaneus culture. Curiously enough, pyocyaneus serum is not more strongly bactericidal *in vitro* than the corresponding normal serum (Wassermann, Paul Müller), and Gheorgiewski has advanced the view that the immune serum owes its protective action *in vivo* to producing an increased phagocytosis. Pyocyaneus immune serum contains, in addition to specific amboceptors, agglutinins and also precipitins that cause precipitation when serum is mixed with filtrates of old cultures. The practical value of agglutination in the diagnosis of pyocyaneus infections has not been determined definitely.

Inasmuch as human pyocyaneus infections are rarely severe, there is little or no call for antipyocyaneus serum. Experimental observations indicate that good results might follow the use of such serum, and opportunities to test it should not be overlooked.

THE STANDARDIZATION OF THERAPEUTIC SERUMS

The serum of immunized animals does not always have the same curative and protective value. Depending on numerous and complicated factors, such as the individual constitution of the animal used, duration and degree of immunization, etc., the potency of antiserums may vary within wide limits. Hence it becomes necessary to establish units for measurements of the strength of serums used for therapeutic purposes. Physicians and patients must have the assurance that the specific serums offered them possess adequate curative and protective value. It is also clear that progress in serum therapy depends on the employment of serums of ascertained quality, so that comparable results may be secured. It appears that the unfavorable

* Jour. Infect. Dis., 1910, vii, 429.

results in England in 1895 in the treatment of diphtheria by serum were due to the use of serums without proper antitoxic strength. It is not possible to weigh or measure antitoxin and other antibodies; their strength is measured by means of their effect on animals.

Antitoxic Serums.—In the case of antidiphtheric and antitetanic serums, the earliest attempts to establish fixed standards were based on the amounts necessary to cure animals injected with the living bacteria. It proved to be very difficult to obtain accurate dosage with living cultures, and in 1893 Behring introduced the use of specific poisons upon which diphtheria and tetanus really depend, and which are neutralized by the respective antibodies. Furthermore, the protective or immunizing value of the antitoxic serums was determined, rather than the curative, that is, the toxin was injected after the antitoxin. But before long it was shown by Ehrlich that if toxin and antitoxin were mixed outside of the body and this mixture injected, more constant and uniform results were obtained than when the substances first meet each other in the animal, in which the conditions of absorption and distribution naturally vary.

The smallest amount of diphtheria poison that will kill a guinea-pig weighing 250 grams in four days is called the *minimum lethal dose*—MLD. At present the antitoxic unit or immunity unit in vogue practically everywhere is that introduced by Ehrlich, namely, the amount of antidiphtheric serum necessary to neutralize completely 200 MLD of pure toxin for guinea-pigs weighing 250 grams. On account of the complexity and variability of the crude diphtheria toxin, as represented in filtrates of broth cultures of diphtheria bacilli, there being no fixed relations between its toxic effects and its power to neutralize antitoxin, Ehrlich found it easier and more reliable to establish an arbitrary standard antitoxin (antidiphtheric serum), by comparison with which the antitoxic strength of any serum may be calculated in immunity units. This standard antitoxin (serum dried in vacuum over phosphoric anhydrid and protected from heat and light) is now used everywhere, and is the basis of the legal standard for this country. While this serum is used to standardize other serums, it must be remembered that this standardization or comparison is accomplished through the medium of diphtheria toxin.*

* A description of the methods by which the immunity unit is obtained, with full details as to preparation of toxin, etc., is given by M. J. Rosenau, Bulletin No. 21, Hygienic Laboratory, United States Public Health and Marine Hospital Service, Washington, pp. 1–92, 1905. In view of the fact that the standard serum (based on Ehrlich's) issued by the United States Public Health and Marine Hospital Service is the official standard for this country, the description of the methods of testing, etc., in this bulletin is official. See also report of Committee on Antitoxic and Immunizing Sera of the Laboratory Section of the Public Health Association, Jour. Infect. Dis., 1905, supplement No. 1, pp. 284–294.

The following is taken from the Pharmacopœia of the United States, Eighth Decennial Edition, 1900:

Serum Antidiphthericum.

Antidiphtheric Serum. Diphtheria Antitoxin.

A fluid separated from the coagulated blood of a horse, *Equus caballus* Linné, immunized through the inoculation of diphtheric toxin. It should be kept in sealed glass retainers, in a dark place, at temperatures between 4.5° and 15° C. (40° and 59° F.).

In actual practice the determination of the strength of the antidiphtheric serum, whether concentrated or not, is carried out according to the following scheme: Unit quantities of the standard antitoxic serum are mixed with varying quantities of toxin and the mixtures injected into guinea-pigs. In this way is determined the exact quantity of toxin that, when added to one unit of antitoxin, kills a guinea-pig weighing between 235 and 275 grams in four days. In other words, the L+ dose (p. 290) is found, and this amount of toxin is then mixed with varying quantities of the antitoxic serum to be standardized. The amount of serum necessary to add to the L+ dose of toxin in order to protect a 250-gram guinea-pig from death on the fourth day is said to contain one immunity unit, being slightly in excess of the standard unit.

Earlier standards for measuring the strength of tetanus antitoxin being unsatisfactory, the following method has been worked out in the Hygienic Laboratory of the United States Public Health and Marine Hospital Service by Rosenau and Anderson, and officially published as the standard for this country: "The American unit for measuring the strength of tetanus antitoxin may be defined as the neutralizing power possessed by an arbitrary quantity of antitetanic serum preserved under special conditions to prevent deterioration in the Hygienic Laboratory of the Public Health and Marine Hospital Service. This arbitrary quantity now contains ten times the amount of tetanus antitoxin necessary to neutralize somewhat less than 100 minimum lethal doses of a standard toxin for a 350-gram guinea-pig—that is, one-tenth of a unit mixed with 100 minimal lethal doses of the standard toxin contains just enough free poison in the mixture to kill the guinea-pig in four days after subcutaneous injection.

"The standardization of tetanus antitoxin does not differ radically from the standardization of diphtheria antitoxin. The toxins and antitoxins are measured against each other reciprocally, so that change or deterioration of either the standard toxin or the standard antitoxin may readily be determined. Duplicate toxins and antitoxins made

A yellowish or yellowish-brown, transparent or slightly turbid liquid, odorless or having a slight odor due to the presence of the antiseptic used as a preservative.

Specific gravity: 1.025 to 1.049 at 25° C. (77° F.).

Antidiphtheric serum gradually loses its power, the loss in one year varying between 10 per cent. and 30 per cent. Each container should be furnished with a label or statement giving the strength of the antidiphtheric serum, expressed in antitoxic units, the name and percentage by volume of the antiseptic used for the preservation of the liquid (if such be used), the date when the antidiphtheric serum was last tested, and the date beyond which it will not have the strength indicated on the label or statement.

The standard of strength, expressed in units of antitoxic power, should be that approved and established by the United States Public Health and Marine Hospital Service.

Average Dose.—3000 units.

Immunizing Dose for Well Persons.—500 units.

Extensive use is now made of a concentrated antitoxin, from which most of the serum constituents, except the part of the globulins that carry the antitoxin, has been removed by precipitation with neutral salts (Gibson).

from time to time will act as checks against deterioration of either the standard toxins or antitoxins.

"The value of an unknown serum is measured indirectly through the toxin, using the L+ dose as the test dose. The L+ dose is the smallest quantity of tetanus toxin that will neutralize one-tenth of an immunity unit, plus a quantity of toxin sufficient to kill the animal in just four days.

"The *toxin* and not the *antitoxin* is given out to licensed manufacturers and others interested for the purposes of standardizing their serums. The L+ or test dose of the particular toxin (a) now dispensed contains just 100 minimal lethal doses for a 350-gram guinea-pig. This particular toxin is very stable, and has not changed appreciably in two years. As soon as it alters or is exhausted the next toxin that will be issued may contain considerably more or less than 100 minimal lethal doses, but the test dose will contain precisely the same neutralizing power.

"The antitoxic serum for the purposes of this standard was obtained from a single horse. The serum was reduced to dryness and ground to an impalpable powder. The powder so obtained is preserved in many vacuum tubes under the influence of pentaphosphoric acid. These tubes are kept in absolute darkness at a constant temperature of 5° C. Every two months or oftener one of these tubes is opened, dissolved in a solution of glycerin 66 parts and isotonic salt solution 34 parts, and tested.

"While the tetanus antitoxin preserved in dry powdered form under the conditions above named is stable, duplicates of the antitoxins made from time to time, so as to guard against loss or change, will insure the permanence of the standard which has now been established." *

Anti-infectious Serums.—The difficulties in the way of standardizing the anti-infectious serums are many, and have not been mastered fully. Anticholera and similar serums may be tested by means of Pfeiffer's method, which is applied as follows in the case of cholera serum: Ten times the minimum fatal quantity of virulent bacteria (eighteen to twenty-four-hour agar culture) are mixed with decreasing quantities of the serum to be tested, and injected into the peritoneal cavity of guinea-pigs (200 grams). The unit of the serum is the amount causing lysis of the bacteria in from forty to sixty minutes after injection, provided the animals remain alive. The peritoneal fluid is withdrawn by means of pipets and examined microscopically in hanging drops to determine whether or not lysis takes place. Control experiments are made in the same way with bacterial cultures alone.

Antistreptococcus serums produced by immunization with animal-virulent streptococci (Aronson and others) are standardized tentatively on the basis of the protection they give to mice and other laboratory animals. Aronson aims to produce a serum 0.5 c.c. of which will protect a mouse against 100,000 times the fatal dose of the

* Hygienic Laboratory, Bulletin No. 43, 1908.

streptococcus used for immunization injected twenty-four hours later. Attempts to secure evidence of protective virtues in the antistreptococcus serums on the market in this country in 1909 by this general method met with uniform failure. The serums, on the other hand, often seemed to reduce the natural resistance and to hasten death.*

From recent experiments on standardization of antimeningitis serum it appears that the uncertainty of the reaction of small animals to the meningococcus precludes their use for this purpose; furthermore, that the method of complement fixation is not practicable because there is no uniformity in the complement-binding power of the serum, and no definite relationship between this power and therapeutic power. Jobling † recommends that antimeningitis serum be measured on the basis of its opsonic content. The immune meningococco-opsonin is a stable body if the serum is kept at low temperature, hence the method would be available for practical purposes. The standard of strength proposed is definite opsonic activity in a dilution of the serum of not less than 1 : 5000.‡ Possibly this method may prove applicable to other serums of this class. So far as antistreptococcus serum is concerned, none of those in the market in this country appear to contain any more opsonin than normal horse serum, if as much. The immune streptococco-opsonin seems to disappear very rapidly, because serums giving definite opsonic power in a dilution of 1 : 6000 when fresh very quickly lose this power, even when kept near the freezing-point.

ANTIVENINS

That immunity to bites of venomous snakes may follow recovery from snake-poisoning was known long ago, and certain races are said to have practised a form of immunization by means of bites of young snakes with venom of low toxicity. In 1887 Sewall immunized pigeons against rattlesnake venom, and Calmette (1892–94) soon demonstrated that antivenins with curative power may be produced. To secure antivenin in large quantities horses and donkeys are used; the immunization must be carried out with many precautions. At first Calmette was of the view that cobra antivenin would prove active against snake venoms in general, and even against the poison of scorpions. It has been shown, however, that different venoms contain different toxic substances, and that cobra antivenin does not neutralize all of them (Martin, Lamb, Fraser). The venoms of the cobra group (Colubridæ) are essentially neurotoxic, while those of the

* Hektoen, Weaver and Tunnicliff, Jour. Amer. Med. Assoc., 1910, liv, 257.

† Jour. Exp. Med., 1909, xi, 614.

‡ To determine the opsonin content either Neufeld's method may be used, in which the readings are based on the gross appearance of the spreads made from the mixtures of serum, meningococci, and suspensions of carefully washed leukocytes, or a modified Leishman method, according to which the included cocci are counted, the greatest dilution of the serum giving a higher count than the control mixture without any serum giving the ultimate strength of the serum.

rattlesnake and the like (Viperidæ) cause intense local lesions, with hemorrhage and blood changes.*

Calmette now holds that the neurotoxic substances in all venoms are one and the same, and always neutralizable by an antineurotoxic serum like that of animals properly immunized with cobra venom.† This serum, which is effective against cobra bites, has but little effect against viperine and other venoms. According to Calmette, an antivenomous serum may be considered to be utilizable when a mixture of 1 c.c. of serum with 0.001 gram of cobra venom produces no intoxicating effect in the rabbit, and when a preventive subcutaneous injection of 2 c.c. of serum into a rabbit of about 2 kilograms enables it to resist, two hours later, subcutaneous inoculation with 1 milligram of venom. It is said that 10 c.c. is sufficient to save life if given less than two hours after the bite. Much larger doses have been recommended, and also that the injection be made intravenously. Calmette now attempts to prepare serums suitable for different localities by first immunizing animals with cobra venom, and then with progressively increasing doses of the venoms of the snakes most frequently met with in the particular districts. Noguchi ‡ has shown that anticrotalus and antimoccasin serums with high degrees of therapeutic power may be obtained. The effects of such serums are highly but not absolutely specific. Noguchi states that "the therapeutic value of antivenin depends on the possibility of preparing an antivenin of higher potency than has been accomplished, and when such an object is accomplished, our specific treatment of snake-bite will be perfect. For the present, beside the use of specific antivenin, the local treatment . . . combined with a general tonic, such as tea, coffee, or alcohol, is indispensable."§

* Weir Mitchell and Reichert long ago called attention to an enzyme in rattlesnake venom that causes local softening of the tissues. Flexner and Noguchi in particular have shown that venoms abound in substances with special affinities—neurotoxic, hemolytic, endotheliolytic (hemorrhagic), and leukolytic substances. Keyes (Jour. Infect. Dis., 1910, vii, p. 1810) has shown that the hemolytic substance is activated by lecithin within the erythrocytes, and that the complete lysin thus produced evokes the formation of a specific antitoxin. Concerning snake poisoning in this country see Wilson, Snake Poisoning in the United States, a study based on an analysis of 740 cases, Arch. Int. Med., i, 516.

† Calmette, Venoms, Venomous Animals, and Antivenomous Serum—Therapeutics, 1908.

‡ Jour. Exp. Med., 1906, viii, 314.

§ Modern Medicine, 1907, i, 265.

THE GENERAL PRINCIPLES OF ORGANOTHERAPY

By Warren Coleman, M.D.

The term organotherapy means etymologically the treatment of disease by preparations of animal organs. Latterly, the term has been made to include the therapeutic employment of any tissue of the body, such as muscle, brain, etc. Organotherapy is as old as the history of medicine itself. Reference to it is found in the papyrus Ebers, but the empiricism of the ancients did not lead to definite results in this field of therapeutics. It was not until after the middle of the last century that organotherapy was placed upon a scientific basis by the work of Brown-Séquard upon testicular extracts, and by a large group of workers upon the thyroid. Since that time the advances in our knowledge of the ductless glands has been slow but steadily progressive.

In the present chapter no attempt will be made to cover the whole range of tissues which have been recommended in treatment, but attention will be confined to the consideration of subjects resting upon the basis of generally accepted facts.

THE ADRENALS

Physiology and Physiologic Actions.—Our knowledge of the physiology of the adrenals is confined to certain activities of the medulla of the gland. Practically, nothing is known respecting the functions of the cortex.

Brown-Séquard discovered, in 1856, that removal of the adrenals causes death. This discovery has been confirmed many times. Death usually follows within two to three days, though it has been reported to occur within a few hours. The principal symptoms after removal are muscular weakness, great prostration, and marked loss of vascular tone. They resemble in many respects the symptoms of Addison's disease. The majority of cases of Addison's disease have been associated with pathologic destruction of the adrenals. In a few cases the adrenals have appeared normal, while, on the other hand, extensive lesions of these glands have been found in persons not suffering from this disease.

Oliver and Schäfer discovered that extracts of the medulla of the adrenals possess remarkable physiologic activities. Abel first isolated the active substance of the extract and suggested for it the name epinephrin. Takàmine obtained the active principle in crystalline form, and called it adrenalin, the name by which it is now generally known.

Blood flowing from the adrenal vein contains demonstrable quan-

tities of adrenalin. This fact makes it practically certain that the adrenals furnish an internal secretion to the blood, and that adrenalin is a constituent part of this secretion. Adrenalin is formed in the medulla of the gland. The cells of the medulla contain a substance, called chromaffin, which stains yellow with chromates, and the physiologic activity of the medulla is proportional to the amount of chromaffin present. These facts constitute the basis of the theory of the internal secretion of the adrenals, which assumes that this secretion is necessary to health, if not to life itself. The other, though less satisfactory, theory is that the adrenals form an antitoxin which neutralizes or destroys certain supposed toxins developed in the body during the processes of metabolism. According to this theory, removal of the adrenals causes death through the accumulation of these toxins within the organism.

Action on the Circulation.—When the vagi are intact, adrenalin causes marked slowing of the heart, marked constriction of the blood-vessels, and a decided rise of blood-pressure. When vagus control has been removed, either by section or by the use of atropin, adrenalin increases the rate and force of the heart and causes an enormous rise in blood-pressure. The initial slowing of the heart is reflex, and is dependent upon the great increase in blood-pressure. The constriction of the blood-vessels is due to the action of adrenalin on the sympathetic nerve-endings in their walls. Langley and Elliott showed that the action of adrenalin corresponds with the effects of sympathetic stimulation. Vessels not innervated by the sympathetic system, such as those of the heart, lungs, and liver, are not affected by adrenalin, and Dixon has pointed out that adrenalin has no action on vessels whose vasomotor nerves have been paralyzed by apocodein.

Adrenalin causes contraction of the ureter, the vas deferens, the seminal vesicles, the uterus, and the vagina. It inhibits the movements of the alimentary tract, except those of the ileocolic valve and of the bladder. Adrenalin dilates the pupil of the eye.

Locally, on mucous membranes and raw surfaces, adrenalin causes marked constriction of the blood-vessels.

Preparations.—The products of the suprarenal gland which are used medicinally are the dried whole gland and the various preparations of the active principle of the medulla, known commercially under different names, but which will be referred to collectively by the term adrenalin. There is reason to believe that the suprarenal contains active substances other than adrenalin, but their existence has not been proved. Adrenalin possesses basic properties, forming salts with acids. It is not affected by boiling for a short time. Solutions of adrenalin and its salts are easily oxidized on exposure to air, becoming pink, then red, then brown. When brown, they are inert. Adrenalin and its salts are supplied in the form of tablet triturates, ointments, suppositories, and solutions. The solutions are said to possess the uniform strength of 1 : 1000, but Schultz and others have shown that they vary.

Adrenalin is also made synthetically. The synthetic product oxidizes quite as readily as the natural alkaloid, and, according to Schultz, Cushny, and others, possesses only about one-half its activity. Moore and Purinton state that an aqueous extract of the medulla is many times stronger physiologically than the so-called pure active principle.

Administration.—The dried gland is supplied both in powder and in tablet form. Extemporaneous solutions of the dried gland are usually made in the proportion of 5 to 10 grains to the dram. Adrenalin solutions for topical use vary in strength from 1 : 1000 to 1 : 15,000.

Solis-Cohen called attention to the fact that adrenalin is absorbed from some mucous membranes, and that the physiologic effects may be obtained by chewing, but not by swallowing, the dried powder. Solutions of adrenalin are difficult to hold in the mouth, and are not suitable for this purpose. It appears doubtful whether adrenalin is absorbed from the stomach and intestine—except the rectum, from which it is absorbed. Bates reports that an adult swallowed the aqueous extract of two pounds of fresh glands without harmful effects. Falta and Ivcovic state that 20 times the toxic intramuscular or intravenous dose is inactive when given by mouth, and suggest that adrenalin is destroyed by the digestive juices. Yet the benefit which follows the oral administration of the whole gland in some cases of Addison's disease is evidence that some constituent, at least, of the gland is absorbed from the stomach or intestine or both. The majority of authors state that adrenalin is not absorbed when injected subcutaneously, because it does not then affect the blood-pressure. Immediate relief is obtained, however, in asthma from such injections, and Miles and Muhlberg have shown that the blood-pressure effects are obtained if the site of the injection is massaged. Intramuscular injections of adrenalin are readily absorbed, but larger doses are required than when the drug is given intravenously. Persons vary in their susceptibility to adrenalin, and Wiggers advises that reliance be not placed on a definite dose.

The dose of the dried gland is 3 to 10 grains. The doses of adrenalin solution usually recommended are: 5 to 30 minims by the mouth every two or three hours; 1 to 15 minims hypodermically, diluted with sterile water, and 2 to 3 minims intravenously, continuously increased, if necessary.

Toxic Effects.—*From Local Use.*—Aqueous solutions of adrenal powder form excellent culture-media for micro-organisms. Bates pointed out that tampons wet with such solutions readily cause infection when left in the nose. Mayer found that the use of adrenalin in operations upon, and in diseases of, the nose was occasionally followed by sloughing, which retarded healing. The occurrence of secondary hemorrhage after nasal operations in which adrenalin has been used is considered by many surgeons a strong objection to it. In some persons the after-dilatation of the vessels of mucous membranes contraindicates the employment of adrenalin. Potts has called

attention to the fact that repeated applications of adrenalin in the treatment of hay-fever may induce persistent turgescence of the mucous membrane, which may with difficulty be corrected. The addition of adrenalin to solutions of cocain, to be injected for the production of local anesthesia, may cause localized gangrene, especially in elderly and badly nourished persons. Adrenalin should not be applied to corneal ulcers, because of the local impairment of nutrition. Pigmentation of the skin and mucous membranes sometimes follows hypodermic injections of adrenalin.

Link has reported a case in which shock rapidly followed the injection of 10 minims of adrenalin, 1 : 1000, into the urethra. The author does not make it clear, however, whether cocain or eucain had been previously employed.

From Internal Administration.—Magnus-Levy mentions a case of hemoptysis in which 20 to 30 minims of adrenalin, 1 : 1000, administered hypodermically, stopped the hemorrhage, but within ten minutes caused great oppression, cyanosis, sweating, hardening of the pulse, and increased activity of the heart. The symptoms persisted for fifteen to thirty minutes. Schuecking injected 20 minims of adrenalin, 1 : 1000, into the vaginal vault and cervix for bleeding. Cyanosis developed in seven minutes, and the respirations became shallow and labored, but there were no changes in the pulse. The respiratory changes disappeared after artificial respiration, but the cyanosis persisted for half an hour. Brodie and Drummond both believe that adrenalin is contraindicated in hemoptysis. Meltzer and Auer consider adrenalin harmful in pulmonary edema. In a case of Bondi's adrenalin appeared to bring out latent tetany. Cerebral congestion, with throbbing, and muscular weakness frequently follow subcutaneous injections of adrenalin.

Josué first stated that repeated injections of adrenalin cause atheroma of the aorta in rabbits. Though apparent confirmation has been furnished by many observers, it may be doubted whether the changes are caused by adrenalin. Kaiserling thinks that our knowledge concerning the production of atheroma by repeated injections of adrenalin is too small to permit conclusions to be drawn. There is no evidence that human arterial sclerosis is caused by hyperactivity of the suprarenals.

Glycosuria is readily produced in animals by hypodermic injections of adrenalin, but has not yet been observed in man. Herter, in collaboration with Richards and Wakeman, showed that intraperitoneal injections of adrenalin also caused glycosuria in animals.

Some cases of Addison's disease have been made worse by adrenal therapy, and several have died under treatment.

Therapeutics.—*Local Uses.*—Adrenalin is employed locally to reduce inflammatory congestion and edema, to control hemorrhages, to facilitate examinations of the nasal passages and their accessory sinuses, and to blanch fields of operation. It is often combined with cocain and other local anesthetics, to prolong their action. When

applied locally in inflammatory conditions, adrenalin is curative only in so far as the ischemia it produces renders the soil less fit for the growth of micro-organisms. Its value lies chiefly in the fact that it prepares the ground for the action of other local remedies.

Eye.—Adrenalin lessens the congestion of conjunctivitis, keratitis, and scleritis. It is rapidly absorbed into the anterior chamber, and appears to hasten the absorption of serous exudates and subcorneal deposits. Adrenalin diminishes intra-ocular tension, and, therefore, is useful in the treatment of acute and chronic glaucoma. Unless the effects are watched, the tension may be reduced too far. Instillations of adrenalin, if employed early, may prevent abscess formation in dacryocystitis. De Schweinitz states that the actions of atropin and eserin are intensified by the addition of adrenalin. The employment of adrenalin in combination with cocain for the production of local anesthesia will be considered later.

Ear.—Adrenalin is employed to reduce congestion and edema about the mouth of the Eustachian tube. Attacks of catarrhal otitis media may sometimes be aborted by the application of an ointment containing adrenalin (1 : 1000) and cocain.

Nose.—An extemporaneous solution of the dried gland is preferred by many physicians for use in the nose. This or a solution of adrenalin and cocain is often employed to facilitate examination of the nasal passages. By reducing the swelling about the openings of the accessory sinuses, adrenalin permits the discharge of inflammatory exudates. Many cases of acute rhinitis, if treated early, may be aborted by spraying the nose with adrenalin (1 : 10,000–1 : 15,000), followed by an antiseptic solution. Stronger solutions than this are likely to cause an undesirable secondary reaction. In some persons the reaction after solutions of any strength is so marked that the treatment is without benefit. Attacks of sneezing frequently follow the application of adrenalin to the nose.

Throat.—As a preliminary to other treatment, adrenalin may be applied in acute inflammation of the tonsils, pharynx, and larynx. Solis-Cohen obtained prompt relief with adrenalin in angiospastic edema affecting the tongue and larynx. In other varieties of edema of the larynx adrenalin is not usually as efficient, but may be tried.

Local Hemorrhages.—Local hemorrhages may be controlled by applications of the desiccated gland, by extemporaneous solutions of the desiccated gland, and by solutions or ointments of adrenalin. Unless the nasal cavity is packed with gauze saturated with adrenalin solution (1 : 10,000), the drug may fail to control hemorrhage from the nose, since the bleeding often comes from one of the large vessels of the anterior part of the septum. In every case such a vessel should be sought for and dealt with appropriately. The bleeding from hemorrhoids may be controlled by suppositories of the desiccated gland or of adrenalin, or by the injection of adrenalin solutions (1 : 2000–1 : 5000). Hemorrhoids are temporarily diminished in size by similar applications, but it is doubtful whether permanent benefit

is derived from such treatment. In hemorrhage from the uterus the cavity may be packed with gauze saturated with a 1 : 2000–1 : 5000 solution of adrenalin. Hemorrhage from the urinary bladder often ceases after injections of a 1 : 5000 solution of adrenalin.

Local Anesthesia.—Adrenalin prolongs the action of cocain as a local anesthetic on mucous membranes, and when injected subcutaneously. Woodward recommends the following method of producing local anesthesia in the eye: The instillation of ten drops of a 10 per cent. solution of cocain, at the rate of a drop a minute; after the fifth drop, one drop of adrenalin (1 : 1000) is instilled. The anesthesia affects the cornea, conjunctiva, iris, and external ocular muscles, and there is no danger of secondary hemorrhage. For operations on the nose, Woodward employs a 10 per cent. solution of cocain, containing adrenalin in the proportion of 1 : 6000, applied on a piece of cotton. He states that there is no danger of secondary hemorrhage if the nose is packed properly after the operation. Braun recommends the following solution for producing local anesthesia according to the Schleich method: Adrenalin solution, 0.7–1 c.c. in 100 c.c. of a 0.1 per cent. solution of cocain. The equivalent of 1 mg. of adrenalin may be injected into healthy persons without undesirable results, and of $\frac{1}{2}$ mg. in the case of those who are debilitated. The possibility of causing localized gangrene by such injections must not be overlooked.

Internal Uses.—*Internal Hemorrhages and Hemorrhagic Diseases.*—Brodie believes that adrenalin is contraindicated in hemoptysis. Frey states that adrenalin augments the hemorrhage. It is certain that the results of adrenalin treatment are not as favorable as in hemorrhages from other sources.

Adrenalin is indicated in many other forms of internal hemorrhage. The method of using the drug differs according to the source and nature of the hemorrhage. In the diffuse bleeding which occurs from mucous membranes, such as from the esophageal plexus in cirrhosis of the liver, from the stomach in gastrostaxis, and from various mucous membranes in purpura and hemophilia, the administration of adrenalin or the dried gland by mouth will probably be sufficient. Large doses may be given without fear of poisoning, since adrenalin is absorbed slowly, if at all, from the stomach and intestine. On the other hand, if the source of the hemorrhage is a large bleeding vessel, such as in an ulcer of the stomach or intestine, the dried gland or adrenalin may be given by mouth for its local effects, but adrenalin should also be administered intravenously or intramuscularly. Wiggers has studied the treatment of such hemorrhages experimentally and has formulated the following conclusions:

Large doses must not be employed, since they may dislodge the clot, and since they always cause a preliminary increase in the hemorrhage. Small doses cause little or no preliminary increase in the bleeding, and shorten its duration. The height of the blood-pressure is the criterion for the use of adrenalin. Its administration should always be closely followed by blood-pressure observations. A dose

sure to be below the limit of safety should first be tried. If no rise in blood-pressure occurs, gradually increasing doses may be injected until a slight elevation of pressure has been produced. This amount will be sufficient to affect the hemorrhage. When bleeding has been profuse and a low blood-pressure exists, it is vital that the hemorrhage should be checked, and that no further lowering of the blood-pressure take place.

Hemophilia and Purpura.—Thomas recommends the application of the dried powder to the bleeding surfaces and the internal administration of 5 grains of the powder every four hours. Schlesinger obtained good results in the treatment of hemophilia from the administration of 6 minims of adrenalin (1 : 1000) every hour, making a total of 7½ drams in twenty-four hours. Cianni gave daily doses of 15 minims of adrenalin (1 : 1000) hypodermically to a patient suffering from Werlhof's disease, with bleeding from the nose, gums, and intestine. The patient began to improve from the third day, the blood disappearing from the stools and the other hemorrhages becoming less frequent and less abundant.

As a Cardiovascular Stimulant.—The transient nature of the action of adrenalin upon the heart and blood-vessels renders it unsuitable for use as a cardiovascular stimulant in acute infective and cardiac diseases; at least, it has not found general favor. On the other hand, it appears to be valuable as a cardiovascular stimulant in some poisonings, in the accidents of spinal and general anesthesia, in collapse following acute hemorrhage, and in operative shock. Gottlieb found that adrenalin, given to animals poisoned with chloral, maintained the action of the heart until the danger-point had been passed. Kothe obtained similar results in animals in collapse after excessive doses of chloroform. Kothe and Duncan have used adrenalin in collapse following spinal anesthesia with stovain and cocain. They treated four such cases in all; in two the heart-sounds were inaudible, and in two the respiration had failed; all recovered. Kothe gave a weak solution intravenously; Duncan gave 4 minims (1 : 1000) intramuscularly.

Hoddick has studied the effects of adrenalin after laparotomy for acute general peritonitis. He gave 8 to 10 minims in a pint and a half of normal saline solution intravenously. Under this treatment 16 of 19 patients recovered: before the employment of adrenalin, 6 of 14 patients died. Heinecke believes that the chief benefit in such cases is from the salt solution, but that the temporary increase in blood-pressure caused by the adrenalin may tide the patient safely over the critical period. Heinecke states, however, that adrenalin injections are useless when the collapse is deep and lasting, thus agreeing with the experimental results of Crile. Meissl reports good results from adrenalin in the collapse following puerperal hemorrhage, and Dengg in that after hemoptysis.

While good results have been obtained in the conditions above mentioned from intramuscular injections of adrenalin, Crile has

shown that the most effective method of administration is a continuous intravenous infusion in salt solution, varying in strength from 1 : 50,000 to 1 : 100,000. During the infusion, blood-pressure observations should be made continuously, as harm may be wrought by overstimulation of the vagus mechanism. In fact, Neu states that the toxic dose of adrenalin, when given intravenously, is 0.00002 gm. (corresponding to 2 to 3 minims of the 1 : 1000 solution). This dose is perhaps too low, but it indicates the caution necessary when administering the drug by this method.

Poisonings.—In view of the results which have been obtained experimentally in animals by Meltzer and by Jona, adrenalin has been recommended in the treatment of alkaloidal and other non-corrosive poisonings, such as morphin, strychnin, aconite, belladonna, and cyanid. The action depends upon the delay in absorption which the adrenalin causes, and, therefore, it must be administered early to be of value. After the poisons have been absorbed, adrenalin is of benefit only as a cardiac stimulant. If the patient is seen soon after the poison has been taken, he should be given 1 dram of the 1 : 1000 solution, diluted, and the stomach should be washed out. A second dose of 1½ drams should be given later.

Januschke's experiments appear to show that adrenalin is an antidote to strychnin only when they are injected simultaneously under the skin; and then because the adrenalin prevents the absorption of the strychnin; when they are injected together into a vein, typical symptoms of strychnin poisoning develop.

Addison's Disease.—The results of adrenal therapy in Addison's disease have been a disappointment, on the whole, yet no other method of treatment offers as much promise of success. Sajous reports that the treatment has been employed in 120 cases of this disease, with little or no improvement in 40 per cent., marked improvement in 30 per cent., and apparent cure, up to the time the cases were reported, in 20 per cent. The cases which have been benefited have shown improvement in the circulatory disturbances, in the asthenia, and in the extent of the pigmentation. Dieulafoy's and Stockman's cases relapsed when the treatment was discontinued, and improved again when it was resumed. The reporters of some of the cases which have apparently been cured have afterward questioned the correctness of the diagnoses, but it is improbable that many were wrong. In a small proportion of cases alarming or even fatal results have coincided with the adrenal therapy, yet sudden death is not uncommon in Addison's disease, and the causative relation of the death to the treatment may well be doubted. In fact, the general opinion appears to be that the risks incurred in the adrenal treatment are very small. Jaboulay believes, however, that death has been hastened by attempts at adrenal grafting. Boinet warns against the employment of large doses of adrenal, and against the treatment altogether in advanced cases.

Our knowledge respecting the best preparation of the gland to be

used and the best method of administering it is far from complete. Adrenalin is more uncertain in its effects than preparations of the dried gland, probably because adrenalin does not represent the whole internal secretion. Magnus-Levy states that adrenalin, administered hypodermically, has produced unfavorable results. The dose of the dried gland for Addison's disease is not fixed, but should be determined for each case individually. The first doses should be small, ½ to 2 grains, three times a day, and should be gradually increased until the dose at which the best results are obtained is reached. This dose should be continued.

Asthma.—Kaplan first called attention to the relief which follows hypodermic injections of adrenalin in attacks of spasmodic asthma. The effect of the drug is not so marked in cardiac and renal asthma, but it may be tried. Adrenalin may be administered for asthma in several ways: Matthews obtained good results from spraying the nose with solutions of 1:1000–1:4000, and from suppositories; Aronsohn recommends the introduction into the nose of a small quantity of the following ointment: Adrenalin solution (1 : 1000), 30 to 60 minims; lanolin and vaselin, each, 1 dram; when given hypodermically, the dose should be 8 to 15 minims in sterile water.

Hay-fever.—Adrenalin brings temporary relief in some cases of hay-fever, but does not alter the susceptibility of the patient to the cause of the condition. Patients must be cautioned against the too frequent or long-continued use of the drug, as it is likely to induce a chronic relaxation of the vessels of the mucous membrane of the nose. Solis-Cohen recommends the use of $\frac{1}{20}$-grain tablets dissolved on the tongue, and states that if the patient can remain in a dark room, one or two doses daily are sufficient; on the other hand, if the patient goes about the street, the tablets must be taken every hour or two. The dose varies with different persons and with the same person at different times. A patient who is accustomed to the drug may require doses of $\frac{1}{10}$ grain, while patients who have never taken it may find $\frac{1}{50}$ to $\frac{1}{40}$ grain sufficient. Adrenalin may be employed also in the following ways: sprays of a 1:1000–1:10,000 solution; the insufflation of a powder consisting of adrenalin, 1 part, and 100 parts of boric acid; or the introduction of adrenalin ointment (1 : 1000) into the nose.

Various Uses.—Zanoni has treated 1000 cases of whooping-cough, at all ages, with adrenalin. He states that he has never had an accident from its use, that the improvement is striking, that the number and intensity of the paroxysms diminish rapidly, and that cure is effected within five to six days. The method of using the drug is not given.

Rebaudi has used adrenalin in the vomiting of pregnancy with apparently good results. Varanini has used it in diabetes insipidus. Barrs recommends injections of 15 minims of adrenalin into the pleural cavity after paracentesis for pleurisy with effusion. It has also been suggested that similar injections be made after paracentesis for ascites, but the experiments of Herter show that such injections would be

dangerous. Adrenalin is probably of no value in the treatment of osteomalacia and rickets.

THE THYROID GLAND

The thyroid gland consists of two lobes, connected by an isthmus, lying on either side of the trachea, immediately below the larynx. Accessory thyroids are often present, and may be found as far down as the heart. They are identical in structure and function with the thyroid proper, and are capable of compensatory hypertrophy. Histologically, the thyroid consists of vesicles of different sizes, lined by cuboidal epithelium, and containing colloid material. The colloid is formed by the lining cells. The vesicles burst and discharge their contents into adjacent lymph-spaces.

Physiology.—Schiff, in 1856, laid the foundations of our present knowledge of the physiology of the thyroid gland by studying the effects of its removal upon dogs—most of the dogs died within a few days with symptoms of experimental tetany. Some of them developed a slowly increasing cachexia, to which they subsequently succumbed. From the work of Gley, Moussu, Vassale, Generali, and others, it is now known that the parathyroids, as well as the thyroid, had been removed from the dogs dying of tetany. It is also well established that removal of the thyroid gland alone causes profound nutritional disturbance resembling clinical myxedema. Reverdin first called attention to the occurrence of this condition—cachexia strumipriva—in man after operative removal of the thyroid. Grafting thyroid tissue into animals from which the gland had been removed was attempted by Schiff, and later by Murray, Eiselsberg, and others. Temporary improvement in the animal's condition always followed, but the grafts were soon absorbed. Later it was found that the deficient thyroid secretion could be supplied by feeding the glands of other animals or by subcutaneous or intravenous injections of its extract, and the animal preserved in a normal state.

The manner in which the thyroid gland presides over the nutrition of the body is unknown. It is generally admitted that it furnishes an internal secretion, that this secretion is formed by the lining cells of the vesicles, and that it is poured into the colloid material they contain. But our knowledge has not advanced much beyond this point. Schaefer showed in 1895 that injection of thyroid extract causes a fall in blood-pressure and slowing of the heart. Small doses increase, large doses decrease, the force of the cardiac contraction. Injections of thyroid extract also increase the excitability of the vagus, the depressor, and vasodilator nerves, and decrease the excitability of the accelerator and vasoconstrictor nerves. Furth believes that the only effect of injections of thyroid extract upon the cardiovascular apparatus is fall of blood-pressure, and that this is not specific, but due to the presence of cholin.

Injections of thyroid extract and thyroid feeding, if continued, give

rise to hyperthyroidism, which is characterized by tachycardia, vasomotor disturbances, severe nervous disturbances, insomnia, increased output of nitrogen and carbon, rise of temperature, and sometimes glycosuria and albuminuria.

Baumann discovered that the thyroid gland contains iodin. The iodin is probably in organic combination with the thyroid globulin, which has been isolated and called iodothyrin or thyreoiodin. Iodin is not present in the thyroid gland of all animals. It is absent in new-born children. The quantity varies in persons living in different localities. If the thyroid gland is diseased, the iodin content is greatly diminished, or it may be absent. An increase of iodin in the food raises the iodin content of the gland. The activity of thyroid extract is proportional to the amount of iodin it contains, yet apparently the glands functionate when iodin free, as in the new-born and some cases of goiter. The above facts state, but do not explain, the physiology of the thyroid gland. Enzymes probably play no part in its function, since the activity of the extract is not affected by heat. The most plausible theory is that the thyroid exerts its influence on nutrition by means of a hormone or hormones,—the "chemical messengers" of Starling,—which act as stimuli to other organs and tissues.

Relation of Disturbances of the Thyroid Function to Disease.—Two groups of diseases must be considered, the one associated with loss or diminution of the thyroid secretion, the other with hyperactivity of the gland.

1. *Diseases dependent upon suppression or diminution of the thyroid secretion.*

Myxedema, cachexia strumipriva, and cretinism are due to ablation of the function of the thyroid. In addition the attempt has been made to correlate a large number of diseases of the most diverse nature, with diminution of the thyroid secretion. These will be referred to later.

2. *Diseases dependent upon hyperactivity of the thyroid gland.*

Exophthalmic goiter, according to one theory of its origin, is due to an excessive secretion of the thyroid. In its later stages, when the gland has become fibrous, the disease takes on some of the characters of myxedema. Larval forms of exophthalmic goiter must not be overlooked.

Preparations.—Treatment of thyroid insufficiency in animals was first attempted by the employment of grafts of thyroid tissue. The method originated with Schiff, who was unsuccessful, and later was carried out by Murray, Eiselsberg, and others. Horsley suggested the application of the method to man, and it has been tried many times, but without conspicuous success. The chief objection to the method is the difficulty in making the grafts "take." Relief of symptoms is afforded, however, until the foreign gland is absorbed.

Mackenzie and Howitz, independently of each other, introduced the method of administering the gland by mouth. The dose of the

gland, raw or slightly cooked, is $\frac{1}{8}$ to 1 lobe (sheep's) per day, though the latter dose is large.

Later glycerin extracts of the gland were given by the mouth, subcutaneously, or intravenously. Glycerin extracts are made by macerating the gland in an equal weight of glycerin for twenty-four hours and expressing the solution. The dose of this extract is 3 to 15 minims daily.

The above methods have been superseded, for the most part, however, by the use of the desiccated and powdered gland. The thyroid of the sheep is generally employed. Attention should be directed to the fact that preparations of thyroid often contain parathyroid substance. The desiccated gland is supplied as a powder and in tablets of different strengths. The *iodothyrin* of commerce is not considered as efficacious as the dried gland. It is not improbable, however, that the thyroid globulin, when carefully extracted and properly standardized, will be found superior to preparations of the whole gland.

At the present time little or no attempt is made to standardize thyroid preparations, with the result that those of different manufacturers vary in strength. It has also been shown that the strength of the product of the same manufacturer may vary from time to time, depending upon variability in the glands of different animals, even of the same species. These facts probably account, in part at least, for the differences in reaction of persons to thyroid, and emphasize the need for a standard product.

Administration.—In view of the above facts it is impossible to give specific directions for administering thyroid preparations. The dose should always be small at first, and be gradually increased according to the needs of the patient. At the first sign of hyperthyroidism the drug should be discontinued or its quantity diminished. It may be resumed when the symptoms have subsided. Thyroid preparations should be given after meals, with an additional dose at bedtime, if required. Rest for a short time after a dose should be enjoined. The powdered gland should be given in capsules or cachets. When using tablets, the physician should ascertain that they disintegrate readily. In some cases it will be necessary to continue the administration of the drug through life, but once the patient has been brought under its influence, it is usually possible to reduce the dose.

Toxic Effects.—The excessive use, or large doses, of thyroid preparations produce an intoxication known as hyperthyroidism. The most characteristic symptoms of hyperthyroidism and exophthalmic goiter are identical. In fact, the excessive use of thyroid has been known to produce the disease temporarily. In both there occur tachycardia, vasomotor disturbances, exophthalmos, digestive disturbances, such as vomiting and diarrhea, severe nervous derangements, insomnia, tremors, rise of temperature, rapid loss of weight, and sometimes glycosuria.

Other symptoms, while not so characteristic, have been reported to occur as the result of thyroid medication: Nausea, general depression, profuse sweating, albuminuria, headache, restlessness, irritability of temper, mydriasis, vertigo, mental confusion with hallucinations, delusions of persecution, melancholia, loss of consciousness, tonic spasms and epileptiform attacks, articular and muscular pains, pruritus, erythema scarlatiniforme, acne, and urticaria. Some of these symptoms have been attributed to products of putrefaction, developed in glands improperly preserved and prepared. Some of them may have been due to independent causes. The possible influence of parathyroid substance, which is sometimes present, must not be overlooked.

Edmunds found that feeding large doses of thyroid to rats caused congestion of, and hemorrhage into, the suprarenals.

In addition to the acute intoxication, chronic thyroid poisoning has been reported, and is characterized by emaciation, muscular weakness, loss of hair, mydriasis, and general debility. Acute and chronic thyroid intoxication, however, are probably not sharply difentiated from each other.

Contraindications.—While preparations of the thyroid should be administered with caution at all times, their employment is definitely contraindicated in the early stages of exophthalmic goiter, as it intensifies the symptoms. At least one case of death has been attributed to this cause. In the later stages of the disease, however, when the symptoms are taking on the form of myxedema, thyroid preparations may be prescribed with benefit. Thyroid is also contraindicated in diabetogenous obesity, tachycardia, cardiac valvular disease with breaking or broken compensation, and diseases of the myocardium. Béclère considers thyroid to be a cardiac poison, and has collected many instances of death by syncope. It need scarcely be added that thyroid or any preparation containing it should not be given to patients suffering from wasting diseases, such as tuberculosis.

Therapeutics.—The employment of the thyroid gland has been advocated in a large number of diseases and conditions. The claims made for it have so often been extravagant that caution must be exercised in accepting the results. However, since so little is known of the physiology of the gland, it is not improbable that the whole range of its therapeutic usefulness has not yet been discovered. For this reason cautious empiricism should not be deprecated.

Up to the present time its field of greatest usefulness is in cases where there is a well-established diminution or loss of thyroid secretion, such as in myxedema, cretinism, etc. Certain other uses of the gland cannot be ignored, however, and, accordingly, the therapeutics of the thyroid will be considered under two headings:

1. *Diseases which are definitely due to loss or diminution of the thyroid secretion.* These diseases are myxedema, cachexia strumipriva, cretinism, the later stages of exophthalmic goiter, when the gland has undergone retrograde changes, and some cases of simple goiter.

The treatment of these diseases is typical of so-called substitution therapy in that the system is artificially supplied with a secretion which has been suppressed. The results of treatment are the same whether we employ the fresh gland, glycerin or other extracts of it, or the desiccated powder, and are among the most striking in the whole range of therapeutics. Recovery is rapid and always complete.

Treatment should be begun with small doses, and these be gradually increased according to the reaction of the patient. One grain three times a day is the amount usually recommended. It is rarely necessary to exceed 10 to 15 grains per day. In cases with complete suppression of secretion the administration of the thyroid must be continued throughout the remainder of the patient's life, but once health is restored, smaller doses are required to maintain it. Neglect of this precaution has led to the development of hyperthyroidism and temporary artificial Graves' disease. After the restoration of health, one of two methods may be followed: minimal doses may be given daily or full doses may be given for several days, at the end of every three or four weeks.

2. *Miscellaneous diseases and conditions which either are not, or have not been proved to be, dependent upon alteration of the thyroid function.* Not all of the diseases and conditions for which thyroid has been recommended will be mentioned, nor does the fact that a disease is mentioned imply sanction of the method.

Obesity.—The use of thyroid for obesity is based upon the rapid loss of weight which often occurs under thyroid medication. This loss affects fat as well as nitrogen. Thyroid has been used for obesity perhaps more than for any other condition.

Self-drugging is common, not so much now with thyroid under its own name, as with proprietary preparations containing it. The practice should be severely condemned. Some obese persons lose weight rapidly; in others the loss is insignificant, even under large doses. Losses due to thyroid are only temporary, and in the opinion of many physicians are always detrimental. They may be dangerous. It is probable that tachycardia, glycosuria, or albuminuria occurs at some time in all cases thus treated.

Chauffard tells of a patient who died suddenly of a cardiac accident after the loss of 35 pounds in ten days. Javal states that a patient with aortic disease died while under active treatment. Thyroid should not be given to obese patients with a tendency to diabetes. Serious accidents are likely to occur if the heart is fatty. Taken all in all, the thyroid treatment of obesity must be condemned.

Delayed Union of Fractures.—Hanau suggested the use of thyroid for delayed union of fractures in 1896, because of the defective growth of the bones in cretinism. Experiments upon animals have led to directly contrary results. Steinlin drew the conclusion that thyroid promoted the healing of fractures in young rabbits; Bircher found that it delayed the union of bones in young rats. Clinical experience has not yet decided the question.

Among the many other diseases and conditions in which thyroid preparations have been used, the following may be mentioned: Chronic rheumatism, arthritis deformans, hemophilia, the so-called thyroid form of migraine, amenorrhea, dysmenorrhea, menorrhagia, incontinence of urine, rickets, scleroderma, chronic urticaria, pemphigus, pruritus, eczema, ichthyosis, psoriasis. In such cases Leonard Williams advises that the initial doses should never be larger than $\frac{1}{2}$ grain three times a day,—it is rarely necessary to exceed $2\frac{1}{2}$ grains three times a day,—and that treatment should be suspended at regular intervals, say for one week out of every four.

THE PARATHYROID GLANDS

The parathyroid glands were discovered by Sandström in 1880. He did not, however, recognize them as anatomic entities, but considered them to be embryonic thyroids. Ordinarily, they are four in number,—two on either side,—lying behind the lateral lobes of the thyroid. Sometimes they are embedded within the thyroid. Accessory glands are often present, some of which may lie within the thymus. The consensus of opinion is that the parathyroid glands are histologically distinct from the thyroid, though they resemble embryonic thyroid tissue. Welsh and others have described two types of cells in the parathyroids,—the chief and the oxyphile,—but Forsyth believes there is only one type, differing in appearance according to its condition of rest or activity. Vesicle formation is comparatively common in the human gland, and a colloid substance is elaborated by the cells.

Physiology.—Two theories respecting the physiology of the parathyroid glands have been advanced. According to the one, the functions of the parathyroid and thyroid glands are essentially the same. This theory is based upon the inconstant results of parathyroidectomy in the hands of certain investigators, and upon the histologic resemblance between the two glands. Forsyth states, upon histologic grounds, that the colloid substance of the two glands is identical, but Beebe has shown that the parathyroid colloid does not contain iodin, while the iodin-content of the thyroid is well known.

The weight of evidence is overwhelmingly in favor of the second theory, which assumes that the parathyroid glands are physiologically distinct from the thyroids, that they elaborate an internal secretion of their own, and that their removal gives rise to characteristic symptoms, invariably ending in death. Judged by this theory, failure to obtain the symptom sequence after parathyroidectomy is due to incomplete removal or to the presence of accessory glands. Berkeley has found that more than seven-eighths of the glands must be removed in the rabbit before the characteristic symptoms develop.

Gley demonstrated in 1891 that removal of the parathyroid glands caused tetany and death, though he considered the parathyroids to

be embryonic thyroid rests. Moussu first clearly differentiated the functions of the parathyroid and thyroid glands. Vassale and Generali performed complete parathyroidectomy on dogs and cats, and obtained the following symptoms: Fibrillary tremors, muscular twitchings, salivation, anorexia, tachycardia, rapid respiration, nervous excitement, loss of weight, and convulsions ending in death within a few days. These observations have been confirmed so often that there can be no reasonable doubt of the causal relation between parathyroidectomy and tetany death.

Partial removal of the parathyroids does not cause rapid death, but is followed first by nutritional disturbances. This fact was noted by Gley. One of the cats operated on by Vassale and Generali developed cachexia and survived for two months. Thompson and Leighton have shown that incomplete destruction of the parathyroids by ligation causes a cachexia in which there occur gradual but progressive loss of weight and strength, greatly diminished resistance to infection, and a stuporous condition ending in death without tetany.

This experimental evidence is supported by observations in man. Before our present knowledge of the parathyroids was acquired, removal of the thyroid (including parathyroids) for tumors and other conditions was frequently followed by tetany. Billroth had a high percentage of postoperative tetany. Today this accident is prevented by the skilful surgeon, who leaves the parathyroids uninjured, *in situ*.

Though its existence has not been proved, there can scarcely be any doubt that the parathyroid glands elaborate an internal secretion, and that the loss of this secretion causes tetany and death. The following facts support this assumption: The symptoms of experimental, postoperative, and medical tetany are relieved by the administration of parathyroid extract. That the relief is only temporary does not vitiate the theory of an internal secretion. Addison's disease is rarely cured by adrenal preparations, yet no one doubts that the adrenals form such a secretion. The results of parathyroid grafting lend additional weight to the theory. Pfeiffer and Mayer successfully transplanted parathyroid glands in two six-weeks'-old puppies, relieving them of tetany. Subsequent removal of the grafts caused a recurrence of the symptoms and death. Berkeley and Beebe have found that the parathyroid nucleoprotein is equivalent to the whole gland in its therapeutic effects.

The origin of the symptoms after parathyroidectomy is still under discussion. MacCallum has advanced the calcium deficiency theory. Berkeley and Beebe have pointed out that this theory does not explain all the facts, and have suggested that the cause of the symptoms is a toxin, or toxins, developed during the intermediary metabolism of nitrogen. In other words, that the parathyroids secrete enzymes which control nitrogen metabolism.

MacCallum bases his theory on the rapid loss of calcium after

parathyroidectomy, the low calcium content of the body after tetany death, and the almost instantaneous relief of the symptoms by intravenous infusions of a soluble calcium salt. It is of interest in this connection to recall Bell's theory that one of the functions of the pituitary gland is to prevent calcium retention, and his belief that the loss of this function is in some way related to acromegaly and gigantism.

MacCallum observed also that the symptoms of experimental tetany could be relieved by bleeding followed by saline infusion. Berkeley and Beebe point out that these procedures reduce the calcium content of the body still further, and that, if the calcium deficiency theory is correct, the symptoms should be intensified thereby. Furthermore, they have shown that the symptoms of experimental tetany may be relieved as quickly by infusions of soluble strontium salts as by those of calcium. Berkeley and Beebe think that the symptoms point strongly to the presence of a poison, resembling those of the convulsant series, such as strychnin, ammonia, and various xanthin substitution products. The symptoms are more severe and develop more promptly in young animals. A meat diet brings the symptoms on more quickly and intensifies them. Analogously, in cases of pregnancy with disturbed nitrogen metabolism, a meat diet predisposes to convulsive seizures. On the whole, the investigations of Berkeley and Beebe appear to demonstrate that the tetanic seizures are not in themselves due to a deficiency of calcium, though they do not prove that control of calcium metabolism may not be one of the functions of the parathyroid glands.

Ott and Scott have investigated the effects of parathyroid extracts upon the function of the kidney. They found that $\frac{1}{10}$ to $\frac{1}{5}$ grain of the powdered extract at first decreases the volume of the kidney and then greatly increases it. The primary decrease is due to slowing of the heart. The subsequent increase is not due to any change in the rate of the heart, and the general blood-pressure at the time fell slightly. As a diuretic, the parathyroid is the most powerful of the glands. The nucleoprotein increases the urine to ten times the normal. Glycosuria (3 per cent.) occurred after the injections.

The Relation of the Parathyroid Glands to Various Diseases and Conditions.—In view of the development of tetany after complete parathyroidectomy, the attempt has been made to correlate tetanoid diseases and conditions with perversion of the parathyroid function. At present the results must be regarded as suggestive only.

Jeandelize attributes tetany in adults to loss of the parathyroid function. This relation has been emphasized by Pineles. On the other hand, Kinnicutt has reported a case of gastric tetany in which the parathyroid glands were normal. This fact, however, does not exclude functional deficiency.

Escherich thinks that the parathyroid theory of tetany explains the frequency of this condition in early life. He believes that there may be functional deficiency without pathologic changes. Hemor-

rhage into the parathyroids is comparatively common in infants; it may occur in older children, and exceptionally in adults. Yanase examined the parathyroid glands of 89 children suffering from tetanoid conditions, in which he includes hypersensitiveness of the peripheral nerves to galvanism, and found hemorrhage in 37 per cent. In all children under one year showing galvanic hypersensitiveness hemorrhage was present. After hemorrhage, the parathyroid function is not always suppressed, and every gradation between simple galvanic hypersensitiveness and tetany may thus result. This fact probably explains the cases of hemorrhage without tetany reported by van Verebély and others.

Lundberg and Berkeley independently suggested that paralysis agitans is due to disturbance of the parathyroid function. Berkeley bases his belief upon the evidence of one autopsy and upon the benefits derived from parathyroid therapy. Thompson, however, failed to find pathologic changes in the parathyroid glands of nine patients dying with paralysis agitans.

Vassale and others have suggested that puerperal eclampsia is the result of disturbance of the parathyroid function. MacCallum attributes the tetany of pregnancy and lactation to the increased demand for calcium in the development of the fetus and the secretion of milk.

Thompson and Harris, in 250 routine autopsies, were unable to correlate any clinical symptoms with pathologic changes in the parathyroids.

Therapeutics.—*Administration.*—Berkeley states that he has found all the commercial preparations worthless, and that he uses parathyroid glands prepared according to the following method: Fresh ox glands are obtained from the abattoir. They are carefully identified, trimmed with sterile instruments, pressed dry between folds of sterile gauze, minced in a finely cutting sausage machine (which must be scalded before use), and rubbed up in a sterile mortar with an excess of milk-sugar. To this mass 1 per cent. of boric acid is added and a trace of essential oil, usually peppermint. The preparation is dispensed in capsules, each corresponding to ½ grain of fresh ox gland. The dose of the capsules is 3 to 5 a day. Beebe's nucleoprotein (1 : 1000) is given hypodermically in doses of 15 minims from five to six or even ten times a day. In the majority of cases one or two doses suffice. Both preparations should be kept on ice. Hypodermic injections should be given with rigid aseptic precautions. It is better to give them under the skin than into the muscles. The site of the injection remains sore for half a day. Abscesses rarely occur. Injection into a vein must be carefully avoided because of the tendency of nucleoproteins to cause thrombosis when injected into the blood-current.

Tetany.—Two cases of postoperative tetany have been reported which were treated with Beebe's nucleoprotein. Halstead's patient had been in a miserable condition for some months, and was much

improved by the injections. Poole's patient developed tetany within four days after an operation on the thyroid. An attempt at parathyroid grafting failed. Improvement in the symptoms was coincident with the injection of large doses of nucleoprotein. Schneider reports a case in which the thyroid was removed for sarcoma. Severe tetany followed. Fresh horse parathyroid produced a favorable effect upon the symptoms. The patient died within a year from recurrence of the tumor.

Eiselsberg reports a successful attempt at grafting in a woman forty-two years old who had suffered from tetany for many years following removal of the thyroid. A similar case has been reported by Garré.

Berkeley relieved the symptoms of gastric tetany by the administration of fresh ox parathyroid by mouth. Loewenthal and Wiebrecht obtained good results from parathyroid feeding in infantile tetany.

Parathyroid preparations apparently produce no effect in eclampsia.

Paralysis Agitans.—Berkeley states that no remedy so far suggested for paralysis agitans has acted so favorably. The best results are obtained from small doses given over long periods. The earlier the case and the younger the patient, the more rapid and complete is the response, but even bedridden patients have been remarkably benefited. Some patients begin to improve within a week, others not for six weeks, and in still others no conclusion as to the result may be possible under three months. Of 26 cases, 5 were not benefited, 3 showed temporary improvement, and 18 grew progressively better during the whole period of treatment.

THE THYMUS

Physiology.—The thymus gland is highly developed at birth, and when compared to the total body weight, is relatively larger at this time than at any other period of life. Before birth it is said to be concerned in the building of blood. The gland increases in size until puberty, after which time it gradually atrophies, many of its cells being ultimately supplanted by fatty tissue.

It has been shown that complete extirpation of the thymus gland in young dogs (Langerhans and Saweliew), in goats, and in rabbits (Fischl) is without influence on the general health and growth of the animals. There are no trophic or rachitic disturbances, and fractures heal normally (Fischl). In the guinea-pig, removal of the thymus does not alter the number of erythrocytes, but decreases the number of leukocytes (Noël Paton). Thymusless animals infected with tubercle bacilli show the same increase of leukocytes as do normal animals, but they do not react to broth cultures of staphylococci and streptococci as in the case of normal guinea-pigs, and they are less resistant to the toxins of these organisms (Noël Paton). Extirpation of the thymus in the guinea-pig is followed by a more rapid growth of

the testes in the male, but it does not hasten the date of the earliest pregnancy in the female (Noël Paton). On the other hand, castration in cattle, as well as in guinea-pigs and rabbits, causes a persistent growth and retarded atrophy of the thymus gland (J. Henderson). In castrated human beings the thymus shows a retarded involution (Calzolari), and a persistence of the thymus has been found in infantilism (Marchiafava). The normal atrophy which begins after puberty is greatly accelerated in cattle when bulls have been used for breeding, and when heifers have been pregnant for several months.

As contrary to the opinions presented above, the statements may be added that after extirpation of the thymus there is an impoverishment of the calcium content of the tissues (Basch, Bracci), general malnutrition, and nervous excitability. Basch states that intravenous injections of thymus extract often kill the animal, with symptoms of tetany.

Persistent enlargement of the thymus gland is found in status lymphaticus, and the gland is enlarged in exophthalmic goiter and Hodgkin's disease. Pappenheimer states that there is a rapid reduction in the weight of the thymus in acute disease, due to destruction of the thymic epithelium, and that in chronic diseases this is accompanied by a replacement hyperplasia of connective tissue.

Therapeutics.—Thymus therapy has not reached a stage where any recommendations for use may be given.

THE SEXUAL GLANDS

Aside from the procreative function, the genital organs of both sexes exert pronounced secondary influences. In the female the development of the external genitals at puberty, the growth of the vagina and uterus, and the onset of menstruation depend upon the presence of normally functioning ovaries. The older theories held this to be due to reflexes through the nervous system, but Halban has castrated female guinea-pigs and found that if ovaries be transplanted within their abdomens, the genitals show normal development. It is, therefore, certain that "chemical messengers," or hormones, which are formed in the ovaries, are the cause of the normal development of the genitals. Removal of the ovaries after puberty results in regressive changes and final atrophy. If, however, the ovaries be only transplanted and not removed, there is no atrophy, and pregnancy may even take place (Grigorieff). If all nerve connections with the uterus and genitalia be cut, there is no atrophy, and pregnancy may take place (Goltz, Reins). Only a part of the normal ovarian tissue is necessary to effect this action. It is maintained that the yellow cells of the corpus luteum furnish the internal secretion (Fraenkel). The influence of the ovaries upon menstruation was shown by Morris, who transplanted the ovaries of a healthy woman into the fundus uteri of a girl of twenty who had amenorrhea and infantile genitals;

she menstruated ten days after the operation. In another case return of the menses followed transplantation of an ovary into a woman who had been castrated two years before (Glass). The same result has been obtained in monkeys, and the menses stop after removal of the grafted substance (Halban). As a rule, the breasts do not develop after castration. If guinea-pigs be castrated before puberty, the breasts remain undeveloped, but subsequent transplantation of an ovary causes their growth. This is not due to nerve influences, for if the mammary gland of a guinea-pig be transplanted on its ear, development and milk-secretion within it may follow pregnancy and parturition (Ribbert). The secretion of milk, however, is attributed to hormones originating in the embryo (Starling), or to those arising from the placenta (Basch). The influence of the latter explains the temporary presence of "witches' milk" in the newly born. It has been found that castration reduces for a time the number of red blood-corpuscles, and it has been suggested that ovarian insufficiency is the cause of chlorosis.

In the male removal of the testes has a similar influence on the external genitals as is exerted by the ovaries in the female. Growth of the external genitals, especially the prostate, depends on the internal secretion of the testis. Removal of the testicles before puberty results in non-development, and removal after puberty in atrophy. Also if castration takes place before puberty, the larynx does not enlarge, as happens normally, and hence the castration of boys has been resorted to to preserve soprano voices. In cattle a bull reaches full growth in one year, whereas an ox requires four years, during which period there is constant growth of the bones. Similar effects are said to be noted in eunuchs. On account of this, castration is said to be of value in osteomalacia. Various authors, however, find no change in the metabolism of calcium and phosphoric acid following castration in adult animals (Lüthje, Heymann, McCrudden).

With regard to the effect of the internal secretions of the sexual glands upon the general metabolism, Loewy found a reduced metabolism after extirpation of the sexual glands and a higher metabolism after administering extracts of ovary and testicle to dogs. Lüthje, however, found no alteration in the metabolism after castration. It may be that the tendency to obesity after castration or after the menopause in women is due to an increased indolence, following the loss of the sexual secretion. However, it also frequently happens that women passing the menopause do not grow fat at all.

Ovary.—*Preparations.*—The use of the fresh ovary and its extract therapeutically has been largely abandoned. The preparation ordinarily employed is the desiccated gland in doses of 2 to 4 grains per day. It is recommended that treatment be continued for ten to twenty days, and then followed by a period of rest. Preparations of the ovary are said to cause digestive disturbances, but otherwise are harmless.

Desiccated and powdered corpus luteum (called lutein) from the

ovary of the cow is also on the market. The dose is 5 to 8 grains three or four times a day.

Ovarian tissue has been grafted into the fundus of the uterus, the mouth of the Fallopian tube, into the broad ligament, and under the skin, for the relief of symptoms due to ovarian insufficiency. Good results have been reported. The method is better adapted to artificial than the natural menopause, and has also been tried in cases of congenital ovarian insufficiency.

Therapeutics.—Ovarian therapy is still on trial. Opinions as to the results of treatment are diametrically opposed. The use of the ovary is confined almost entirely to the treatment of conditions which are believed to be dependent upon loss or insufficiency of the internal secretion of the gland. Dalche thinks that the accidents of the menopause furnish the best indication for ovarian therapy.

Menopause.—Artificial and the natural menopause will be considered together. The best results are obtained in young women from whom the ovaries have been removed. As a rule, the improvement lasts only during treatment, but in exceptional cases is said to persist. The claim is made that, under ovarian therapy, the vasomotor phenomena, the palpitation, the trembling, and nervous disturbances rapidly disappear. The irritability of temper, the tendency to melancholia, and the asthenia improve more slowly. On the contrary, the assumption of masculine characters seems not to be affected. The results of treatment are often not so evident in the natural as in the artificial menopause. Saalfeld reports improvement of eczema, acne, and prurigo occurring during the menopause. In opposition to the above claims, McDonald states that he has not been able to affect the accidents of the menopause by the use of the whole ovary. The *corpus luteum* has not been used in a sufficient number of women at the menopause to permit any expression of opinion as to its value.

Congenital Ovarian Insufficiency.—Patients suffering from this condition are of small stature; the monthly periods are irregular, scanty, and often lacking. In addition, they are frequently constipated, chlorotic, and hysteric. Mainzer states that doses of 8 grains of desiccated ovary, two to four times a day, caused the appearance of the menses in one patient, but did not affect the hysteria. In the absence of menstrual troubles, ovarian insufficiency is believed to cause chlorosis. This condition appears to be benefited at times by ovarian therapy (Muret, Spillman, Etienne).

The *psychoses* of menstruation, pregnancy, and the puerperium sometimes improve under ovarian therapy.

Obesity.—Employment of the ovary is stated to be beneficial only when the obesity is associated with some phase of the sexual life

Among other conditions for which ovarian therapy has been recommended, the following may be mentioned: virilism, amenorrhea, dysmenorrhea (when of ovarian origin—Jayle), chronic rheumatism, vomiting of pregnancy, and osteomalacia.

Mammary Gland.—The desiccated gland is given in doses of 5 grains from three to six times a day. Overdoses are said to cause cardiac palpitation. Good results have been claimed for the mammary gland in menorrhagia, metrorrhagia, subinvolution of the uterus, and uterine fibroids.

Testicular therapy has not been proved to have any place in modern therapeutics.

THE PITUITARY BODY

The pituitary body consists of two lobes, the anterior, or hypophysis, and the posterior, or infundibular body, which is composed of the pars nervosa and an investing layer of epithelial cells known as the pars intermedia. The anterior lobe is glandular in structure, resembling the fetal thyroid. The pars nervosa is composed of nerve-cells, neuroglia fibers, and ependymal cells. The anterior lobe and the pars intermedia are derived embryologically from the epithelium of the mouth cavity. The pars nervosa is formed by a downgrowth from the floor of the third ventricle, and is connected with the brain by means of a stalk which is known as the infundibulum.

Physiology.—The physiology of the pituitary body is imperfectly known. The two lobes of the gland appear to possess different functions. Cushing thinks that the gland may be regarded as a double organ, with apparently two internal secretions, that from the anterior lobe discharging into the blood, that from the posterior lobe passing through the pars nervosa into the cerebrospinal space.

The effects of removal of the pituitary body have varied in the hands of different investigators. Marinesco, Paulesco, and Reford and Cushing state that removal leads to the development of characteristic symptoms—cachexia hypophyseopriva—which are invariably followed by death. On the other hand, Gaglio, Lo Monaco, and Van Rynberck failed to obtain even notable disturbances of health after removal. Masay's experiments with cytotoxic serum appear to confirm the statement that removal causes death. He succeeded in producing a condition resembling cachexia hypophyseopriva. Among other symptoms, he obtained muscular weakness, progressive emaciation, disturbances of locomotion, and changes in the skeleton. More recently, Cushing has published further studies upon the functions of the pituitary body, in which he confirms his earlier results.

Oliver and Schäfer showed in 1895 that extracts of the whole gland cause a rise in blood-pressure. Howell discovered in 1898 that the presser substance is present only in the posterior lobe. According to Herring, it is formed by the cells of the pars intermedia; according to Vincent, in the pars nervosa. Cushing believes that the secretion of the posterior lobe is less important physiologically than that of the anterior lobe, in that removal of the posterior lobe causes no obvious disturbances, while removal of the anterior lobe, the posterior remaining *in situ*, is equivalent to removal of the whole gland.

Mairet and Bosc, Pariset, and Delille gave pituitary extract to

healthy men by mouth and by injection, and produced malaise, slight elevation of temperature, slowing of the pulse, increase of blood-pressure. These symptoms lasted for twenty-four hours.

Johnston found that pituitary extract given in the food caused an increased output of nitrogen and phosphates. Schiff thinks that the gland presides over the nutrition of the osseous system, because extracts of it produce an excessive loss of phosphorus. Bell reached the same conclusion through a study of the calcium metabolism. He believes that one function of the pituitary body is to prevent calcium retention, and that loss of this function is concerned in the bony overgrowths of acromegaly and gigantism. Ingestion of the dried posterior lobe causes a constant loss of weight in rabbits.

The relation of the pituitary body to various diseases and clinical conditions has been much discussed. Marie first called attention to the association of tumors of the gland with acromegaly, yet acromegaly has occurred when the gland was apparently normal. Both acromegaly and gigantism appear to be related to perversion of function of the anterior lobe of the pituitary body, possibly, hyperactivity. Other clinical conditions which have been found associated with perverted pituitary function are: Polyuria, glycosuria, amenorrhea, impotence, genital infantilism, and pathologic obesity.

The active principle of the extract of the posterior lobe has not yet been obtained in pure form. It is not destroyed by boiling. The investigation of the physiologic effects of injections of extracts of the pituitary body has been confined largely to extracts of the posterior lobe.

Infundibular extract is a general stimulant of plain muscle, having a selective action upon that of the arteries, spleen, uterus, and intestine. When given intravenously, it produces a marked rise of blood-pressure, probably from direct action upon the walls of the blood-vessels. The rise in blood-pressure is less marked, but more prolonged, than that caused by adrenalin. After a transient increase in rate the heart is slowed and the beats become more powerful. Howell thinks that infundibular extract acts partly on the cardio-inhibitory center and partly on the heart muscle. The heart is affected, though to a less degree, when the vagi are cut, or when the animal is under the influence of atropin. According to Pal, infundibular extract contracts the coronary and dilates the renal vessels, differing in these respects from adrenalin. Bell states that the rise in blood-pressure, both in animals and man, is greater in the condition of shock than in health. Howell found that the rise in blood-pressure persists in the normal animal for twenty to thirty minutes or longer with maximal doses; according to Bell, the rise in shock persists for several hours. Injections repeated at intervals of half an hour or so produce a much less marked effect, or none at all, in healthy animals. It is not known how long this "immunity" lasts. Howell was not able to obtain any effects from infundibular extract when it was administered subcutaneously.

Action on the Kidney.—Schäfer and Magnus discovered the diuretic action of infundibular extract. After initial vasoconstriction, the vessels dilate and the kidney enlarges. The diuresis is due to dilatation of the renal vessels, while the general blood-pressure remains high. It is more marked than that produced by citrated caffein. Pal found that the increase in the urine is produced by subcutaneous as well as by intravenous injections, but that it is not so great.

Action on the Intestinal Muscle.—Bell and Hick observed in their experiments that infundibular extract causes contraction of the intestinal muscle, generally violent in character. The peristalsis is greater when atony or paresis is present. Exceptionally in the normal animal it does not occur.

Action on the Uterus.—Dale discovered that infundibular extract causes uterine contractions. According to Bell, the contractions are more powerful and more prolonged than those produced by ergot. It acts equally well upon the menstruating, the pregnant, and the puerperal organ, and as well or better when it is atonic as when contracting.

Local Action.—Applied to mucous membranes, infundibular extract produces local anemia and is non-irritant. Its action is slower and more prolonged than that of adrenalin, but apparently not so pronounced.

Therapeutics.—*Preparations.*—The commercial preparations of the pituitary gland which are upon the market are the desiccated whole gland, desiccated anterior lobe, and liquid extracts of the posterior lobe.

External Uses.—The fact that infundibular extract produces local anemia has suggested its use as an astringent similar to adrenalin. If employed, the commercial preparations should be diluted three to ten times with normal salt solution. It has not yet been tried out sufficiently to permit its recommendation, but it has been used with some degree of success in the treatment of hay-fever.

Internal Uses.—The respective therapeutic fields of preparations of the anterior and posterior lobes of the pituitary body have not been clearly defined. In general, when the term pituitary extract is mentioned in the literature, it means a preparation either of the whole gland or of the posterior lobe, unless the contrary is stated.

It should be repeated here that Howell was unable to obtain physiologic effects when he gave infundibular extract subcutaneously, though Pal produced diuresis by this method. Therapeutic results have been obtained, however, by subcutaneous and by intramuscular injections, and metabolic disturbances follow pituitary feeding.

The infundibular extracts are recommended in doses of 10 to 30 minims by mouth, and in doses of 2 to 15 minims hypodermically. Intramuscular injections into the gluteal region are apparently best. The drug is slowly absorbed when given by mouth. Apparently, it has not been used intravenously. Infundibular extract is toxic only

in doses much larger than those recommended for therapeutic purposes.

Cardiovascular Conditions.—Whether infundibular extract will prove to be a valuable cardiac stimulant is still an open question. It has been tried in a limited number of cases, apparently with good results, but it is too soon to draw conclusions. One of its most important uses is in shock. Mummery and Symes and Bell and Wray have reported cases in which infundibular extract seemed to be the determining factor in the favorable outcome. As with adrenalin, infundibular extract cannot replace infusion with normal salt solution. It is given to raise the blood-pressure temporarily, and thus to carry the patient through the critical period of vasomotor breakdown. The dose of the extract for this purpose is 15 minims intramuscularly. In view of the "immunizing" effect of the drug, it should not be repeated too soon, but second doses have been given in an hour, apparently with good result.

Infundibular extract has been employed as a cardiac stimulant in typhoid fever, erysipelas, pneumonia, pleurisy, meningitis, puerperal septicemia, and pulmonary tuberculosis. Trerotoli gave a watery extract of the posterior lobe to twelve patients suffering from cardiac or renal disease. The liquid was sterilized at the boiling-point. There was an increase in the size of the pulse-wave; the pulse became slower, and, if irregular, it became more regular; the blood-pressure was increased as much as 20 mm. Hg, the rise being greatest fifteen to twenty minutes after the injection, and persisting for an hour or more. Trerotoli observed no unpleasant effects, either general or local, but Delille reports a case of myocarditis in which infundibular extract brought on violent angina pectoris. Atheroma of the aorta and stenosis of the coronary arteries were discovered at the autopsy.

Paresis of the Intestine.—Infundibular extract has been used for postoperative and other pareses of the intestine. It should be given as soon as the patient begins to distend. Bell has used it in a limited number of cases, and states that he has never known it to fail. The effect is generally observable within a few minutes. It should be given in doses of 15 minims intramuscularly, and may be repeated in an hour. If the condition does not subside, similar doses may be given on succeeding days.

Uterine Conditions.—Bell gave infundibular extract to two cases after Cesarean section, and observed that the uterus contracted down into a blanched ball, with only slight subsequent relaxation. He states that it is valuable also in uterine hemorrhage, whether occurring during or after labor. While it should only rarely be given before labor, it has acted well in placenta prævia.

Exophthalmic Goiter.—Renon and Delille and Pariset have used the extract of one-half to one gland a day in exophthalmic goiter. They state that all the symptoms improved, and that the improvement lasted for three to four months after the cessation of the treatment.

Acromegaly.—In the early stages of acromegaly extracts of the

whole gland (and anterior lobe?) are not only useless, but may be dangerous. In the later stages their administration has been followed by some amelioration of the symptoms, such as disappearance of the headache, slowing of the pulse, improvement of the intelligence, and diminution of the sweating and of the asthenia. In some cases the extracts have appeared to increase the intensity of the symptoms. The number of cases in which it has been employed is so small that specific recommendations cannot be given.

THE REST CURE, THE WORK CURE, AND PSYCHOTHERAPY

By Charles W. Burr, M.D.

A rational discussion of the rest cure, the work cure, and psychotherapy necessarily entails also a discussion of neurasthenia, the condition in which these therapeutic measures find their chief and greatest usefulness. I shall not confine the word neurasthenia for the purpose of this article to its narrow and strictly scientific meaning, but shall use it in its wider, more popular, medical sense. So used, it includes not only primary neurasthenia, properly so called, and the neurasthenic state secondary to some other disease, but many types of nervous and mental aberration too varying in their symptomatology to be classified with precision in the present state of knowledge, such as borderland insanity, the milder but not the more severe forms of hypochondriasis, overtire, pure emotional breakdown, and obsessions. In other words, I shall use it to include all conditions save hysteria, in which the therapeutic question is, Which is needed, rest, work, or psychotherapy? Primary neurasthenia is a definite and rather rare disease, though a secondary neurasthenic state is a frequent result of acute and chronic illness. Primary neurasthenia is due always to hereditary (ancestral) or, at any rate, congenital (all those antedating birth) causes, and is characterized by too great susceptibility to stimuli, the responses being also themselves abnormal, not only in quantity, but in quality, and too rapid fatigue, without any discoverable underlying physical basis. Though it has no known morbid anatomy, our lack of knowledge does not prove there is none. Its exciting internal cause is more probably chemical than structural, even when the external cause is mental strain, and there is probably always some underlying anatomic, developmental, cellular defect. Whether such defect is in the cells of the cerebrum and medulla, making them react abnormally to stimuli, or in those of certain glands, especially the ductless glands, resulting in the production of poisons which act upon the nervous system, is unknown. It seems to be proved that in some cases disturbance of function of the abdominal viscera may either be causative or symptomatic, or may act in a vicious circle. It is possible that the correct explanation is a congenital weakness of the entire organism, on account of which the cells can resist strain only up to a point far below the normal, and that as one or another organ or system of organs breaks down first, the early symptoms will be referred to them. In other words, there is a universal "abiotrophy," in Gower's sense of the word. Certainly mental stress and strain, either acute or chronic, can disturb function, and

when long continued, alter structure. The neurasthenic state occurring in people previously normal, and resulting from disease of the heart, lungs, kidneys, etc., is purely secondary. There is arising, especially among laymen, an opinion that primary neurasthenia has no physical basis, but is purely mental, not only in symptomatology, but in its very nature. This view, carried to a logical conclusion, presupposes a psyche—a something existing, yet non-material, which controls matter. Such an opinion is beyond scientific discussion, because the question of the existence of a psyche is a metaphysical rather than a medical problem, and is outside the domain of formal science. Such an opinion is not to be confused with the certainly correct one, admitted by all, that mental or emotional stimuli, either normal in nature but excessive in amount, or in themselves abnormal, may cause physical symptoms and, indeed, physical lesions. In this sense neurasthenia may be just as properly called psychasthenia. Secondary neurasthenia, as said above, is merely a symptomatic condition due to many different causes, and occurring in or after many diseases, such as chronic myocarditis, hookworm, beginning phthisis, syphilis, influenza, indeed, all the acute infectious fevers, and chronic ague poisoning. The error of mistaking secondary for primary neurasthenia may have serious untoward results, because it may lead to the omission of the use of very important drugs. For example, to put a syphilitic neurasthenic on a rest cure and not give the proper medicine may end disastrously. Every patient suspected to have neurasthenia should be carefully examined to exclude all possible primary disease.

There is no need, in this article, to give a detailed account of the symptomatology of neurasthenia. A brief outline will suffice. I shall describe the primary type, saying of the secondary only that while the patient may on any one day, especially if examined superficially, seem to be truly and purely a neurasthenic, yet if his history be carefully inquired into and a proper physical examination made, it will be found either that the neurasthenic symptoms followed some acute illness, or there will be signs of existing organic disease somewhere in the body. The curve of the time of frequency of onset of symptoms runs parallel with the curve of age throughout adolescence and early maturity; it falls a little about thirty-five, more rapidly until forty, and then very rapidly. Primary neurasthenia never occurs in old age: it would be impossible for it to do so, because an organism that can withstand the stress of a long life must be congenitally strong, though as a secondary symptom of arterial sclerosis it is not rare. In children the primary form is very rare, but symptomatic neurasthenia is not uncommon, and is not infrequently due to an acquired chronic disturbance of gastric or intestinal digestion. A certain number of boys and girls begin soon after puberty unaccountably to show signs of weakness. They lose interest in play, become languid and physically inert. Though as children they did well at school, they now fall behind. They complain of headache and backache and become peevish or even extremely emotional. In most instances the matter

rights itself, and is a mere temporary loss of balance from the strain of puberty, but occasionally it is the beginning of a long prodromal stage of true neurasthenia. Primary neurasthenia is more common in females than in males. The opinion that it is a disease confined to the wealthy and socially well placed is one of those idle notions, without foundation in fact, which owe their origin to ignorance and the desire, sometimes subconscious, to use a term of the newer psychology, natural enough in those of us whose lives have not been put in pleasant financial places, to increase the catalogue of evils due to wealth. School-teachers, workers in mills and stores, and overworked house-servants are much more frequently affected than the women who never work at all, in the restricted sense of the word work. Idleness and indolence take inevitable toll from their victims, but in other forms than neurasthenia. Civilized races are more prone to it than uncivilized, and an overdeveloped or wrongly developed emotional nature is both a potent causative factor and part of the symptomatology of certain types of the disease. Some kinds of religiosity and of metaphysical pseudo-thinking are alike fruitful soils for its growth and symptoms of its existence, but the commonest exciting cause is the mere stress and strain of ordinary life. The weakest victims break without any unusual strain because they are too weak to stand the mere stress of development; others only after extreme strain. The greater the stress required to produce breakdown, the better the outlook as to cure, because the stronger and more nearly normal must have been the original nature. Among individual exciting causes, the shock arising from trauma is very important, and the habit of surgeons of getting patients up too soon after a surgical operation produces not a few cases. In adolescence the awakening of the sexual sense often leads to aberration, and not infrequently abuse and vicious habits lead to serious breakdown.

The onset of illness may be either rapid or slow. Usually there is a stage, lasting an indefinite time, in which the patient simply feels nervous, tired, and weak, and this is followed by the rapid or even sudden appearance of serious symptoms. Disturbance of sleep is almost always a very early symptom. At first sleep is merely unquiet, and dreams are frequent, but soon great restlessness comes on and the patient sleeps but little, and thinks continually throughout the night. The cause of the insomnia is always mental unrest and inability to inhibit thought. The weakness becomes excessive, and is not only physical, but there is mental inability and often emotional instability. Added to this are headache, especially a feeling of strain or "drawing" in the nape, of a band around the head, vague pains elsewhere in the body, shifting in position and varying in character from paresthesias to intense pain, anorexia, indigestion, diarrhea alternating with constipation, and sometimes insufficient urine; subjective cardiac palpitation and paroxysmal dyspnea are common. The symptoms finally involve almost all the organs of the body. The appetite and digestion are poor, and the bowels constipated.

Much stress has been laid upon disorders of menstruation not only as symptomatic, but also as causative. Painful menstruation is common, and the womb is often infantile, but this latter is merely one of the many signs of lack of proper anatomic development. In some patients many stigmata of degeneration are present, and they are signs of failure in normal development, but every one, healthy or unhealthy, has a few minor ones, and they are of importance only when numerous. Only the roughest guess can be made of one's nature from the anatomic makeup. The great symptom is weakness, muscular, mental, and emotional, shown by too rapidly oncoming muscular fatigue, inability to think or control the matter of thought, and loss of emotional stability. The physical lack of strength may be so great when the disease is fully established that even to stand is too great an effort. There is no true palsy, but no prolonged muscular work can be carried out. Emotional tremor, especially of the hands and of the muscles around the mouth, is common. The mental weakness shows itself by inability to carry on sustained mental effort, and the emotional, by variability of mood and too great and improper emotional response to stimuli. The occurrence of true delusions takes the case out of the neurasthenic class. There is almost always marked emotional depression. During the early stages the condition waxes and wanes—one day the patient feels well or fairly well, the next miserable, and vice versâ. The symptoms vary with the time of day, morning being the worst, evening the best, time. The special senses, especially vision and hearing, are also soon fatigued. Reading causes headache and unrest. Vertigo is common. Vision blurs with the use of the eyes, and on examining the fields they contract, with tire as the examination continues. There may be reversal of the fields, but this is more significant of hysteria. The judgment is preserved so far as the patient can form an intellectual judgment at all, that is to say, she never forms an insane judgment, but all attempts to think cause such tire that she cannot make the effort to form a judgment requiring real and long-continued thought. At first she can whip her mind to work, but before long she gives up and can think only of her own miserable state. The emotional state is almost always affected, and emotional judgment lost. She no longer has a proper idea of the relative emotional value of things. There may be apathy, depression, or peevishness, according to the character of the patient. Selfishness is prone to be increased, but there is no destruction of the moral sense affecting conduct in the higher affairs of life. Apprehension of some impending evil is a common early symptom. The business man approaches opening his morning mail with a vague fear that it will contain bad news. Later, or at the same time, he begins to lose confidence in his judgment. He loses emotional control, and things that formerly would not have troubled him in the slightest are now heavy burdens. His temper becomes uncertain, or rather it is certainly and persistingly variable.

Patients suffering in the way described above alone have neuras-

thenia in its proper sense, but as used popularly, several other conditions are included. They are important from the point of view of this article, because the question always arises whether the patient needs rest or work, or a combination of both, and how far, if at all, psychotherapy will be useful? True hysteria, which is often confused with and sometimes even mistaken for neurasthenia, is often helped, indeed cured, by rest treatment, but it is a well-defined disease which is treated elsewhere in this volume, and hence I shall say nothing about it. I shall also say nothing about those pretended invalids, more often women than men, who are not ill, but are mere mental and emotional, partially self-deceiving hypocrites, pretending to be sick because they enjoy being nursed and petted and made much of, nor of the men who feign illness throughout life to escape work and responsibility. Wholesome neglect of their complaints, started early in their "illness," is the best treatment. Sometimes wrestling with them in spirit may make them reform, but they are prone to be confirmed offenders and irreclaimable. I shall consider only those suffering from general nervousness, as we must call it, for want of a better name—the somewhat smaller class who are neither sane nor insane, the people who live in a borderland of mental and emotional unbalance, and those suffering from obsessions. The first are not very ill, but yet suffer much; the borderland patients do not always suffer much themselves, though, as a rule, they do, but cause much grief to those who care for them. The obsessed suffer much. All except those suffering from general nervousness are seriously ill, even though their symptoms may seem trifling, because they are always congenitally "queer," though their queerness may not appear to the superficial observer until adolescence or even mature life. "General nervousness" is simply the distress, mild depression, or "feeling of hurry all over," as they describe it, that comes to many people, even the congenitally healthy, when they have been subjected to a strain greater than is good for them. Its symptoms are nervousness, restlessness, inability to hold attention, with little or no physical weakness. As a rule, it is of slight importance, and is cured by a little diversion, a temporary change of manner of living, and outdoor play and life, but sometimes it is the prodromal stage of a serious breakdown.

The borderland cases are much more interesting and much more serious. The victims are people predestined to be abnormal and unlike others, and yet with a measure of normality. Sometimes the struggle between the normal and abnormal elements in them continues a drawn battle throughout life. Not infrequently they are of a high grade intellectually. Some of them recognize their abnormality, or at least their unlikeness to other people, and are much troubled by the knowledge and bravely fight against it. There are two great classes: (1) Those in whom the emotional disturbance is greater; (2) those with an almost purely intellectual disturbance. The first are often religiously upset,—have queer notions,—sometimes distinct delusions; others, both men and women, are sexually

aberrant. They sometimes have an excess of conscience, and still more often an abnormal twist, causing it to hypertrophy in some directions and to atrophy in others. They have much religiosity, but not much religion. They may exaggerate the importance of certain elements of religion, and forget that personal morals and religion have some relation to each other. They are devout, but ill living. They are always self-centered and selfish, though they may imagine they are very altruistic. Some are forever tearing up their souls to see if their spiritual growth is progressing. Others want to tear up other people's souls. The sexually aberrant are often innocently so—unknowingly suffering from sexual hunger. Not infrequently, where there is a sexual origin, either they are congenitally aberrant in sexual feeling or they have become the victims of acquired unnatural habits. Not infrequently they are normal in feeling at the time of illness, but become morbidly fearful of and unduly conscientious about the result of early errors in conduct. The second class show any one of many intellectual twists which make them look at life from a wrong angle.

PROPHYLAXIS

Preventive treatment is vastly more useful in all diseases than curative, and every physician who has much to do with these unfortunate people has brought home to him the question, Could or could not such an one have avoided the condition he is now in had his environment been different in childhood and youth? By environment is meant, of course, all the external influences which act upon us except disease. To every physician is ever present the question, Is Pestalozzi's fable of the two colts true or false? Is the nature of a child mere clay fashioned by his teachers, or is it metal or stone, which may be polished, roughened, or even broken by circumstances, but not inherently changed? Surely some natures are so fixed by inheritance and the incidents of fetal life that environment can alter them neither for better nor worse. Others are so soft, so malleable, that every wind of circumstance changes them. Such people are made healthy by a good environment, provided it lasts until they become fixed, until their intellectual and emotional reflexes are habituated to react normally, and until the physical organization is strengthened by proper food and exercise, and ruined by a bad environment, but from a scientific viewpoint susceptibility to environment is in itself a hereditary trait.

Good training and good education can do much for children and youths. But today many of us forget that the best education—the most important element in all education, far more important than knowledge—is the ability to control self. Education has come to mean ability to read and have opinions; it ought to mean ability to control the emotions and to regard things quietly and sanely. The acquirement of mere book-learning is of little importance in the maintenance of health. Indeed, evil may result from trying to make

scholars of people nature never intended to be such. I have more than once seen an ambitious mother wreck a boy mentally by pushing his school education too far and too fast. On the other hand, I have seen boys mentally so superior to their parents that they have been warped and dwarfed by their association with them.

After the theoretic and practical teaching of self-control, physical play is the most important element in the maintenance of health. All young animals need it, and man, even in maturity, but many a boy and girl get no wholesome play after childhood is over. Many, indeed, never get it even then. The boy who has opportunity for physical play is kept from much emotional mischief. The boy who loses interest in play is already ill; he who never had it is a genius or an imbecile.

THERAPEUTICS

The first question in dealing with these very different types of people is whether they need a strict rest cure, a real work cure, diversion, exercise, and play, mental treatment, or a combination of all. When there are extreme weakness, great nervous tire, and the vegetative functions are not properly carried on, but the emotional state is normal, absolute physical rest is needed, but separation from the family is not required. When, in addition, there is great nervous unrest, the emotional nature is unbalanced, and the intellectual power is decreased, slight mental effort causing great mental fatigue, not only physical rest is indicated, but the rest cure in its technical sense. When there is not much real physical weakness, but mere ennui, loss of interest, a little disturbance of sleep, a rather poor appetite, mere diversion, outdoor life, and play may be all that are required. When, without great physical weakness, there is a perversion of the attitude toward life; when the patient begins to have queer thoughts, to be morbid and self-accusatory; when transient delusions or semidelusions or obsessions appear, a work cure with wise psychotherapy is the one thing which will do real good.

The Rest Cure.—The rest cure consists of bed rest, isolation, massage, electricity, and regulation of diet. Medicines play but a minor part in it. The cure is almost of necessity only possible away from home, but there is one exception to this: when the emotional attitude toward the family is not disturbed and physical weakness and mental tire alone exist, the treatment may be carried out at home. The best place to carry out the strict rest cure is a well-appointed rest house, but this is quite expensive. A hospital for nervous diseases, even if the patient is in a ward, is the next best, and for poor people even a ward in a general hospital is often better than the patient's own home. There are many reasons why absence from home is beneficial. The patient escapes the trials of hearing about housekeeping; family discussions, arguments, appeals to try to control herself and see things reasonably are avoided, and the quiet and discipline of the new surroundings are themselves useful. The nurse is a very important

element in carrying out the cure. No kind of nursing requires as high a type of woman. She must be tactful, strong, kind, and, above all, have no nerves, and possess a superabundance of common sense. Some neurasthenics are fretful, peevish, selfish, and consequently say and do things which greatly offend and hurt the feelings of nurses unless they have a great deal of practical philosophy. Patients sometimes even say disagreeable things to and about their doctor, which, of course, is very improper, but under the circumstances not altogether unnatural.

At first the patient should remain in bed all the time, except to go to the toilet. Very rarely the physical weakness is so great that a bed-pan must be used. For an hour each day she may lie on a couch in order that the bed may be aired and remade. In order to overcome the evils of absolute muscular inactivity massage is necessary. But massage is more than a negative good. It gives the patient exercise without effort or expenditure of nervous energy, stimulates the peripheral circulation and the glands of the skin, mechanically squeezes out muscle poisons into the lymphatic channels, and finally—and this is of no little importance—it has a very wholesome mental influence. The treatment should be general, as a rule, *i. e.*, the whole body should be massaged, but certain abdominal conditions make it better not to treat that part of the body. It does not matter very much what time in the day the massage is given, except that it should always be at about the same time every day, and should not be given within an hour of meal-time. In many women it aids sleep, and in such cases should be given in the evening. In rare instances women are made very uncomfortable by it. They either have an antipathy to being handled, or break out in sweat and become very weak. Usually after a few treatments this passes off, but sometimes massage must be abandoned. The treatment should be given daily except Sundays, and should at first last about a half-hour, and later forty-five minutes.

Faradic electricity is also useful because it gives the muscles exercise. The only apparatus required is the ordinary nurse's battery. The electrodes should be covered each time they are used with fresh absorbent cotton wetted in warm salt water. The two electrodes are held a few inches apart, over the bodies of the muscles, and, the slowly interrupted current having been turned on, each muscle is made to contract two or three times. The electrodes should never be placed over the bones, but always on the body of the muscle. It takes about forty-five minutes to go over the arms and legs. The muscles of the chest may be left alone. About eleven o'clock in the forenoon is the best time for treatment. The feeling of strain in the occiput and back of the neck is often relieved by the use of the rapidly interrupted current. A small electrode is placed on the nape, and a large electrode on the soles of the feet, and the current allowed to pass for about ten minutes.

The next important element is *isolation*. When there is no emotional disturbance and only physical and mental tire, it may be

omitted. At the beginning it is best for the patient to see no one but the doctor, the nurse, and the masseuse. As noted above, there is one exception to this. In the relatively rare cases in which, with great physical weakness and mental tire, there is no or almost no emotional unbalance, the family and a few friends may see the patient. Indeed, under these conditions the patient may be treated at home. It is, as a rule, wisest to prohibit the receiving of long letters. Men must not be permitted to attend to any business. As time passes she may see her family, at first for a short time only.

Every morning she should have a bath. At first the nurse should give a sponge-bath in the morning and an alcohol rub at night. Later the patient may take a morning tub-bath. As a rule, this ought to be warm, but some patients do better with a cold momentary dip or shower.

Food is, of course, important. At first and for a time milk with lime-water every two hours from seven in the morning until nine in the evening is the best diet. Later a noon meal may be given—a little meat, fruit, bread and butter, and a vegetable. Warm cocoa on first awaking in the morning should be given from the start, but at no time tea, coffee, or alcohol. Alcohol is harmful to all neurasthenics. As time passes breakfast may be added, and finally a light evening meal. All neurasthenics should dine, when they are well enough to take meals, in the middle of the day and not at night.

The daily roster should be, after the exclusive milk diet has ceased and meals are being taken, about as follows:

7.30 A. M.: Cocoa or malted milk. Bath.
8.30 A. M.: Light breakfast.
11.00 A. M.: Faradic electricity.
1.00 P. M.: Dinner.
3.00 P. M.: Massage.
6.00 P. M.: Light supper.
8.30 P. M.: Alcohol rub.

After a few weeks the patient should begin to get up for a little while, at first for only fifteen or twenty minutes, then the same twice daily; then for a longer time. She should at the same time read a little, do fancy work, modeling in clay, and thus gradually resume the duties of life.

Medicines do not play a large part in the rest cure. It is sometimes necessary to use hypnotics, though often a hot evening bath or the wet sheet will give good results. When drugs must be used, the bromids or veronal are probably the best and safest. Morphin, of course, must not be used. The milk diet is prone to cause constipation, and the aloin, belladonna, and strychnin pill or the fluidextract of cascara is then useful. Sometimes a daily enema is better.

It is impossible to foretell how long a rest cure should last, nor how soon the patient should begin to get out of bed. The guide is, of course, the progress toward recovery. If things go well, after about four or five weeks the appetite will return, the patient herself will begin

to feel stronger, the circulation will be normal, sleep will be refreshing, the muscles firm, the skin a good color, the emotional tone healthy. When these things occur, it is time to begin a more active life.

A word must be said about the contraindications to rest cure. The sexually neurasthenic are hurt by it. They need a physically active outdoor life. The congenitally indolent are made more lazy and more selfish by it. Persons suffering from true melancholia, even if delusional, provided they are physically weak and with digestive disturbances, are helped in the early stages by a short cure away from home, followed by rest combined with a work cure. Chronic delusionals are best treated by exercise and outdoor life.

Psychotherapy.—Mental influence is of greater or less therapeutic importance in all kinds of disease. It is especially of value in treating nervous patients who are suffering from functional ailments and in mild cases of mental aberration. In dealing with the really insane it is of no value, because the insane are either so self-centered that they are invincible to all impressions from other persons, or if demented, have no mind to be influenced. Self mental influence, true auto-suggestion, may also exercise either a good or bad effect upon the patient. An optimist has greater chance of recovery than a pessimist, and a self-reliant person than a clinging one. The personality of the physician is of importance, because the man who, without pretense and affectation, can inspire confidence, does more good than the man who shows he is not himself sure of his ability to grapple with the case. The man who has the *éclat* of an assured reputation and position has an easier task than the unknown man. These statements are, of course, mere platitudes, but the well-known effects of mental influence on bodily function, such as that the cry of murder may momentarily stop the heart and make the face blanch, that fright may cause relaxation of the sphincters, that intense mental attention may prevent all feeling of what, under ordinary circumstances, would produce intense pain, that shame brings a blush and horror dries the mouth, that pleasant surroundings increase ability to digest, and disgust or fear stops digestion, and that encouragement may make the weak man put forth greater effort and thus himself help himself toward recovery, has led to the building up of schemes of purely mental therapeutics which, when carried to their end, put to one side all other modes of treatment by medicine and mechanical means and the physical forces, and result in the belief in the immateriality of disease.

Though psychotherapy has been carried to wild excess, like most popular error, it contains an element of truth and, properly used, is valuable. It has come to be mixed up with religion, and that which formerly had for its function the explanation of the universe and the making of a rule of righteous living, has been debased into a cure for typhoid fever. It has gone so far as to deny the existence of disease save as a mode of thought, and claims that good thoughts can abolish all disease. At the present time the "school" has much vogue, but, of course, it will in due time go the way of all its predecessors. It has

done some harm in unbalancing the orthodox faith of people who much need orthodoxy; it has done more by preventing proper medical attention when it was most needed. It is of great interest as an example of what power hysteria may have in influencing many people not themselves hysteric, and thus affecting the thought of the world. I do not wish to be thought to be casting any slur on religious belief; on the contrary, religion has saved many people from nervous and mental breakdown, and a frank talk with and advice from a wise clergyman have helped tremendously many a soul-sick man and woman.

Hypnotism is one of the earlier kinds of psychotherapy, and had quite a little vogue before the recent religious forms of treatment came into use. It has been claimed to have cured almost all chronic diseases. There is no real evidence that it has ever influenced any organic disease in any way. Hysteric attacks have certainly been cured by it, though I doubt if it has ever eradicated the hysteric constitution. Hysteric drug habitués also have surely been relieved by it, but, so far as my personal experience goes, they have not remained cured, though every one has often seen an appeal to conscience and an awakening of the sense of family duty, which is a real mental therapy, cure men of the alcohol habit. On the other hand, I have seen evil result from the frequently repeated hypnotization of susceptible youths and maidens. I have seen distinct weakening of the will, and, in a few cases, sanatorium treatment was necessary for upset minds. It is a bad thing for a woman to think she can be in any way under the occult influence of a man. Of late "normal suggestion"—suggestion without hypnotization—has come to the fore. It is no new thing, but has been in use since man and woman first influenced each other by methods of indirection. From the beginning of time "normal suggestion" has been used, but, it seems, we have been like the gentleman who talked prose all his life without knowing it.

Wholesome mental suggestion is of great value in treating the nervous and mentally unbalanced. It is a large part of the rest cure. There are quite a number of people who become frightened about their future mental health, who fear they are becoming insane, who become the victims of pseudo-hallucinations or pseudo-delusions, or who become obsessed by some horrible thought, who can be greatly helped by being simply sensibly talked to or by being led, they being unconscious of the object in view, into new methods of life, new trains of thought. There are many people, not so ill as these, who become emotional, fretful, and unable to do any mental work because they cannot fix their attention, who also can be aided by similar means.

The Work Cure.—It is of use in many types of illness. In true neurasthenia it should always follow a rest cure, but in other cases it should be employed from the start. There is a relatively large number of people falsely called neurasthenics who really are not suffering from neurasthenia at all, but from a congenital nervous and mental twist which may not show itself until they are subjected to the stress and

strain of life. Their strength is not decreased, but misdirected. Another group is made up of the people who need something to interest them. Their lives are and always have been empty and worthless, and they grow weary. Some such are born with fairly good minds, but have never had any proper outlet; others are suffering from an unsatisfied, often an unrecognized, emotional hunger, and still others are obsessed: some thought, always horrible, is ever with them or comes repeatedly to consciousness and cannot be put to one side. The most frequent obsessions are fear of suicide, religious doubt, fear of sin, fear they are spreading disease. Then there is the man or woman who has started out in life healthy enough, but who has simply had too great a burden put upon him and has been compelled to lead a life of monotonous grind, when his very nature needed change, and to whom life finally becomes stupid, dull, and not worth the while. Finally, there is the mild hypochondriac, not the man who has a distinct and definite delusion of some organic illness affecting him, though even for him the work cure is helpful, but the man who is worried about his condition without being made seriously mentally ill by the worry, who wonders whether he is not getting this, that, or the other disease, whether his heart is not beating too rapidly or not occasionally dropping a beat, whether his bowels are in good condition, whether it is safe for him to eat everything, or whether he ought not to be on a special diet. All these people differ among themselves and are all difficult to treat, but all need not rest, but occupation. The treatment may be very simple or very difficult. The overtired and consequently nervous business man may need nothing but a little outdoor play, golf, horseback-riding, or a camp life. He does not need rest from occupation, but a temporary change of occupation. He needs an avocation. But when more serious symptoms arise, it is best to get the patient away from his family and put him under regular systematic treatment, preferably in a small institution where patients suffering in the same way are being treated. The influence of other patients, especially the fact that the newcomer sees others who have improved, and the routine and discipline are all of great value. In women especially interest is awakened by seeing others doing things. What work is to be prescribed must depend upon circumstances and the character of the individual, but it should be largely manual. There should, however, usually be some mental relaxation. Many people are greatly helped by being taught to use their hands—a much neglected part of education. For them carpentering, cabinet-making, and basket-making are good. Others may be given garden work or even real farm work. A good mental exercise is to teach them to observe the lives and habits of the common animals of the woods and fields. The skill of the physician is shown in the choice of work he makes for different patients. During the régime attention must be paid not only to the regulation of the work, but also to hours of sleep, diet, bathing, and the very uninteresting but important matter of the condition of the bowels.

EXERCISE, MASSAGE, AND MECHANOTHERAPY

By R. Tait McKenzie, M.D.

The term "exercise," as employed medicinally, comprises all movements, voluntary or passive, including manipulations by the hand of an operator or by a machine designed to act on the muscles, the blood-vessels, the nervous system, the skin, and the abdominal organs. It has always been used with success in the treatment of many diseased conditions, as well as for the prevention of the sequels of a sedentary or slothful life. Exercise is—(1) Active and (2) passive.

(1) *Active exercise*, whether in its more complicated form of games and gymnastics or in simple duplicate directed movements with assistance or resistance by the hands of an operator or by a machine, requires a definite exertion of the will power.

(2) *Passive exercise* does not require any exertion of will power. The manipulations of massage by means of the hands or by the machines of Zander and others, by which contracted muscles and ligaments are stretched and nourished, local nutrition improved, nerves stimulated, and the abdominal organs made to function, are restful rather than exhausting to an overwrought brain.

ACTIVE EXERCISES

Active exercise may be subdivided into those involving a *single effort* of one or more muscle groups, such as lifting a weight or performing a feat on the horizontal bar, and those of *endurance*, consisting of motions rhythmically repeated without great muscular expenditure for each one, and depending for their effect upon continuous repetition.

Exercises of effort may be more or less violent in character or compound in motion, each one starting from and ending with rest. They are in endless variety, from simple movements of lifting and throwing, to the complicated combinations of the horizontal bar. In them the element of skill plays a leading rôle, and what the expert would regard as a mild exercise may be a severe strain to the beginner, whose inaccuracy means the clumsy employment of many muscles that help little in its accomplishment, if, indeed, they do not actually retard success. In the accurate performance of an apparently localized movement the distribution of muscular effort is wide, and increases tremendously with the difficulty of the feat. In pushing up a heavy dumb-bell to arm's length above the shoulder, the extensors of the elbow-joint alone are usually considered, but the entire muscular

system shares in the effort. The grasping muscles of the hand and forearm, the rotators of the scapula attached to the spine and ribs, the erector spinæ and the muscles of the hip, thigh, and legs, are used for support and balance. A single simple effort may thus fatigue more than the muscles most obviously employed.

Games and feats of speed, in which many movements must be repeated as quickly as possible in a certain limited time, may well be classed as exercises of effort, since all the conditions of a single effort apply to them. In a 100-yard dash, occupying ten seconds, the concentration of attention is continued at its highest point throughout. The breath is held, and the whole muscular system is convulsed with supreme effort, while the blood-pressure rises much as it does in the single effort of throwing or lifting. If, however, the rate be reduced and the runner be allowed twenty seconds or more to cover this distance, the nervous tension disappears, and the blood-pressure is but little affected. The same exercise thus becomes one of mild endurance, and the possibility of this transition in the same exercise from effort to endurance, or from endurance to effort, must be constantly borne in mind, to avoid the confusion that will occur from the careless use of these terms.

Feats of skill, such as juggling, are composed of isolated efforts which may be so mild in nature and so often repeated that they insensibly shade off into feats of endurance, especially when practice has made them almost automatic.

The striking of a fortissimo chord on the piano is an exercise of *effort.* The practice of one scale for an hour is an exercise of endurance, but the playing of the Thirteenth Rhapsody of Liszt combines both effort and endurance.

The qualities cultivated by exercises of effort, whether of strength, skill, or speed, include mental concentration, rapid response of the muscle to the will power, ability to learn complicated coördinations, and the knowledge of the easiest and most economic way of performing difficult movements. Their practice is followed by an increase in size up to the physiologic limit of those muscles most employed in the exercise. If carried past the limit of their power, the muscle will refuse to contract, or may actually tear, and if habitually overworked, they may atrophy and become hard and fibrous, with weak, uncertain movements.

Exercises of effort do not cultivate constitutional vigor to the same extent as do those of endurance.

Exercises of endurance are more limited in the range and variety of their movements. They are confined to a few well-known varieties, such as walking, running, and rowing, and although each movement is well within one's power, the amount of muscular work is great. The rate of contraction being comparatively slow, the fatigue products can be eliminated almost as fast as they are produced, a fact in which they differ from exercises of effort, where fatigue of the more active muscles sets in rapidly; the heart and lungs have insufficient time

to do their work, and so postpone its onset, as occurs in the milder exercises of endurance.

These exercises deal with coördinations familiar from infancy. It is not necessary in walking, a typical exercise of endurance, to concentrate the attention on each movement. The mind is usually otherwise employed, and the qualities cultivated by exercises of endurance are different from those required in effort. Skill is not prominent among them. Concentration is replaced by automatism, and the development of a single muscle group is secondary to the indirect effect on the circulation and respiration in training them to remove the fatigue products of muscular contraction.

When carried to excess, exercises of endurance are accompanied by acute constitutional exhaustion, shown in breathlessness, from which recovery is rapid, by fatigue of the whole muscular system, from which a rest of a day or two is necessary, and by a chronic or nerve fatigue, from which recovery may be a matter of weeks or even months.

Active exercises, when voluntary, take the form of sports, games, and gymnastics, particularly during adolescence, and the extension and popularity of these games would make their classification of value. It is difficult to give such a table with any degree of exactness. In a familiar exercise like walking the change in speed from three to five miles an hour will elevate an automatic, listless occupation into a vigorous exercise, employing many new muscle groups, and stimulating the heart, lungs, and skin, while the change from a smooth level road to the broken ground of a mountain-side may be dangerous to one who might walk on level ground at a moderate speed with benefit.

In the tables on pp. 337 and 338 the muscles employed are named approximately according to the intensity and duration of their action, and the notes in the column "Demand on nerve control" refer to the concentration required, the degree varying with the difficulty of the movement.

The influence on respiration and circulation of an exercise is indicated by the onset of breathlessness and increase in the blood-pressure and pulse-rate during its practice.

The chief characteristics cultivated by the constant repetition necessary for success in such games come in the fourth column, and the age limits within which they should be practised are placed in the last but one. The time of life for beginning and leaving off any exercise must vary greatly with the individual, but the ages mentioned are not far out for the average man. The upper age limit in all cases is placed at sixty. If, by that time, a man has not determined what form of exercise is most suitable for his condition and constitution, he is not likely to be capable of receiving guidance from this chart.

If indulgence in a sport has been continued with regularity, a man's own feelings as to when it must be abandoned are often better indications that any fixed rule. It is dangerous, however, for any elderly gymnast to attempt his youthful feats after a long interval

of idleness and disuse, and however long he may have lain fallow, he is often unwilling to accept the limitations of his years.

CLASSIFICATION OF ATHLETIC GAMES AND EXERCISES.

Exercise.	Chief regions of the body used.	Demand on nerve control.	Influence on pulse, blood-pressure, and respiration.	Physical characteristics cultivated.	Best age for practice.	Remarks.
Baseball.	Right (or left) forearm, shoulder, and the whole muscular system to a lesser degree.	Great.	Moderate.	Accuracy, speed, and agility.	12–35.	Amount of exercise depends on the position played; pitcher has his pitching arm constantly overworked.
Bowling.	Right forearm, arm, shoulder, and back.	Great.	Slight.	Accuracy and strength.	14–60.	
Boxing.	All of forearm, arms, shoulders, chest, back, and thighs.	Extreme.	Great.	Alertness, agility, strength.	16–40.	
Cricket.	The whole muscular system moderately; right or left forearm, arm, and shoulders.	Great.	Moderate.	Accuracy, speed, and agility.	12–60.	Depends on position played; exercise obtained by bowler is different from that of the fielder.
Cross country running.	Thighs and legs.	Slight.	Extreme.	Endurance, speed, and strength.	18–25.	A severe test of the heart.
Dancing.	Thighs and legs.	Extreme.	Great.	Endurance and agility.	14–40.	Clog and soft shoe exercise only the legs, but many acrobatic postural and esthetic dances bring in the trunk and arms.
Football (socker).	Thighs and legs.	Moderate.	Great.	Agility, speed, and strength.	12–35.	In this game the ball is not touched by the hands, but is kicked by the feet and butted by the head only.
Football (Rugby).	The whole muscular system.	Extreme.	Great.	Accuracy, endurance, speed, and agility.	16–30.	The most severe field game on the heart and lungs.
Golf.	The whole muscular system moderately.	Extreme.	Slight.	Accuracy.	12–60.	The walking interrupted by the strokes of the game make it peculiarly valuable for those living a sedentary indoor life.
Hammer-throwing.	Shoulders and back, also arms and thighs to a lesser degree.	Extreme.	Slight.	Accuracy and strength.	16–50.	A difficult feat of coordination as now practised, *i. e.*, from a 7-foot circle.
Hand-ball.	The whole muscular system, particularly the back.	Great.	Extreme.	Accuracy, speed, and agility.	12–40.	
Hockey.	The whole muscular system, especially the back and right (or left) forearm.	Extreme.	Extreme.	Speed, agility, accuracy, and endurance.	12–25.	An extreme test on the heart and lungs.
Hurdling.	The whole muscular system, especially the abdominals, thighs, hamstrings, and calves.	Extreme.	Great.	Speed, agility, and endurance.	16–25.	The high hurdles (3 ft. 6 in.) require great accuracy.
Jumping (high).	Thighs, lower back, and shoulders.	Extreme.	Slight.	Agility and speed.	14–25.	Jumping without a run cultivates agility only.
Jumping (broad).	Thighs, calves, back, and shoulders.	Great.	Slight.	Agility and speed.	14–25.	
Lacrosse.	All the muscles of the legs and arms.	Great.	Extreme.	Speed, endurance agility, and accuracy.	12–30.	A running game.

Classification of Athletic Games and Exercises.—(*Continued.*)

Exercise.	Chief regions of the body used.	Demand on nerve control.	Influence on pulse, blood-pressure, and respiration.	Physical characteristics cultivated.	Best age for practice.	Remarks.
Mountain-climbing.	Thighs, legs, and back.	Slight.	Extreme.	Endurance.	16–40.	A severe test on the heart and lungs, particularly in high altitudes.
Pole-vaulting.	Forearm, arms, shoulders, abdomen, thighs, and legs.	Extreme.	Slight.	Agility and strength.	14–25.	
Riding (horseback).	Back, abdomen, and thighs.	Slight.	Slight.	Balance.	14–60.	The mechanical shaking has a distinct therapeutic effect.
Polo (pony).	Right or left arm back, abdomen, and legs.	Extreme.	Great.	Accuracy, balance, and strength.	16–30.	
Running 100–200 yds.	Whole muscular system, especially the thighs and calves.	Extreme.	Great.	Speed and alertness.	12–30.	A typical exercise of effort.
Running, 440–1000 yds.	The whole muscular system except the arms.	Great.	Extreme.	Speed and endurance.	17–25.	A severe test on the heart and lungs.
Distance running (1 mile and upward).	Thighs and calves.	Moderate.	Extreme.	Endurance.	17–25.	A severe test on the heart and lungs.
Rowing.	Back, forearm, arm flexors, shoulder muscles, and thighs.	Slight.	Extreme.	Strength and endurance.	10–40.	Thighs are practically unused, except with the sliding seat.
Shooting (hunting).	The whole muscular system, especially the thighs, legs, and back.	Slight.	Moderate.	Endurance.	16–60.	Value depends on tramping over irregular ground and open air.
Target.	The whole muscular system, very moderately. Arm flexors and all of forearm.	Extreme.	Slight.	Accuracy.	14–60.	
Shot-putting.	Right (or left) forearm, triceps, shoulders, back, and thighs.	Great.	Slight.	Strength, speed, and agility.	16–50.	
Swimming.	The whole muscular system.	Moderate.	Great.	Endurance and strength.	12–60.	Racing and diving are extreme tests on the heart and lungs. Swimming for distance at a moderate speed is a test of endurance and stamina.
Tennis.	The whole muscular system, especially right (or left) forearm and arm.	Great.	Moderate.	Accuracy, speed, agility, and endurance.	14–40.	Tennis-elbow is caused by constant repetition of back-hand stroke, producing strain of pronator radii teres muscle.
Walking.	Thighs, legs, and back.	Slight.	Moderate.	Endurance.	16–60.	Two to four miles an hour is mild exercise. Four to six miles may be exhausting if kept up very long or if road is rough.
Water polo.	Whole muscular system.	Extreme.	Extreme.	Endurance, strength, and agility.	16–25.	An extreme test of the heart.
Wrestling.	Whole muscular system, especially neck, back, arms shoulders, and abdomen.	Extreme.	Great.	Strength, endurance, agility, and speed.	16–40.	

From the standpoint of therapeutic effect, or even of rapid development, most athletic games are inaccurate and wasteful of time. For these purposes they do not compare with the accurate movements of formal gymnastics. Games and gymnastic exercises especially designed for a specific purpose can be applied to remedy defects or weakness more quickly and surely than sports whose object is recreation alone. No game growing up in a community of children could teach alertness like Dr. Sargent's "curtain ball," a game in which two courts are separated by a curtain eight feet high, each side attempting to throw a basket-ball so as to touch the floor of its opponent's court and at the same time defend its own from a similar fate.

Here, again, it must be borne in mind that, in addition to the circles on the horizontal bar, the swinging exercises on the flying rings, vaults on the horse, and balancing exercises on the parallel bars, the same exercise may be interchangeable from one piece to another.

For the healthy boy or girl of eighteen or thereabouts the best development would be obtained by a judicious mixture of gymnastic and athletic exercise in the open air.

A course should be designed so as to employ all the activities of the muscular system—strength, accuracy, speed, agility, and endurance—as naturally as possible.

A period of gymnastic exercise should begin with a ten-minute drill, including movements for both arms and legs, with special emphasis on correct carriage of the body and on deep breathing. This should be followed by exercise in rope climbing, on the parallel bars, horizontal bar, or flying rings, in which the arms are used; following this, exercises of agility, like vaulting over bars or the German horse, and simple ground tumbling. Each lesson should conclude with running or with a gymnastic running game of sufficient speed to test the endurance. The period should occupy one-half to three-quarters of an hour, and should be repeated at least three times a week. If alternated with walks or out-of-door games, the maximum development and general education of the physical powers should be obtained. The mental exhilaration arising from the emulation and competition that is found in a large class is an influence by no means to be neglected, especially in the young, although exercise will have its effect whether this be present or not, just as surely as iron or castor oil.

For those of mature age and a sedentary life, exercise should be directed principally to the muscles of the arms and trunk, care being taken not to overtax the circulation. Such exercises as throwing the medicine ball,—a large ball weighing from seven to twelve pounds, —hand-ball, and other ball games, combined with simple apparatus work, are usually effective and interesting. If combined with the fresh air obtained in a game like golf, tennis, or a brisk walk in the country once or twice a week, the result would be increased efficiency in business and a general feeling of well-being. For those of advancing

years the necessity for active exercise becomes less urgent, and the individual usually develops some plan to suit his own case.

In the following table the main characteristics of the more familiar pieces of gymnastic apparatus are classified:

CLASSIFICATION OF GYMNASTIC APPARATUS, EXERCISES, AND GAMES.

Exercises.	Chief regions of the body used.	Demand on nervous control and coördination.	Influence on blood-pressure, pulse, and respiration.	Physical qualities cultivated.	Approximate age limit.	Remarks.
Basket-ball.	The whole muscular system especially legs, thighs, and lower trunk.	Extreme.	Extreme.	Agility, accuracy, and endurance.	16–30.	An extreme test on the heart.
Bom (Swedish).	Flexors of fingers, wrist, and forearm, flexors of arm, all of shoulder, and abdomen.	Moderate.	Slight.	Strength and balance.	16–40.	
Buck.	All of forearm, arm, and shoulders, thighs, and legs.	Moderate.	Slight.	Agility, balance, accuracy, and precision.	12–40.	Thighs and legs exercised principally during approach and finish of movement.
Flying rings.	Flexors of hand, wrist, forearm, shoulders, and abdominals.	Great.	Moderate.	Strength, rhythm, and balance.	16–30.	
Horizontal bar.	Flexors of fingers, wrist,forearm,arm, pectorals, latissimus dorsi, and abdominal muscles.	Extreme.	Moderate.	Strength, balance, and rhythm.	16–30.	
Horse (long).	All of forearm, arm, shoulders, abdomen, thighs and legs.	Moderate.	Moderate.	Agility, balance, and strength.	14–30.	These exercises are vaulting and leaping, and so develop thighs and legs more than side horse.
Horse (side).	All of forearm, arm, shoulders, abdomen, thighs and legs.	Extreme.	Slight.	Balance, accuracy, rhythm, agility, and strength.	12–40.	Thighs and legs developed in the approach and finish, but much less than arms and shoulders.
Ladders.	Flexors of fingers, wrist, forearm, arm, pectorals, and latissimus dorsi.	Slight.	Slight.	Strength.	14–60.	
Medicine ball.	All of forearm, arm shoulders, back, abdomen, and chest.	Slight.	Slight.	Strength and accuracy.	14–60.	An excellent exercise for developing all muscles above the pelvis.
Parallel bars.	All of forearm, arm, shoulders, pectorals, abdomen, and latissimus dorsi.	Great.	Moderate.	Strength, balance, accuracy, and rhythm.	16–30.	Influence on coordination depends greatly on the intricacy of the exercises practised.
Spring-boards.	All of thighs, legs, and lower back.	Great.	Moderate.	Agility and accuracy.	12–30.	
Trapeze.	Flexors of hand, wrist, forearm, and arm; all of shoulders, the abdominals, and latissimus dorsi.	Extreme.	Moderate.	Balance, strength, and accuracy.	12–30.	One set of exercises are for equilibrium only; another are like the typical horizontal bar exercises in their effect.
Tumbling.	The whole muscular system, especially legs, back, and neck.	Extreme.	Great.	Rhythm, agility, strength, balance, and accuracy.	14–30.	One of the best all-around exercises.

The outstanding quality that differentiates passive from active exercise is its power to feed muscular tissue without fatiguing or even employing the will power of the patient. It is thus a most economic form of exercise on the nervous system, and yet its potency is shown by increase in red blood-corpuscles and hemoglobin, and by the exalted rate and force of the heart-beat, without a corresponding change in arterial tension. It accomplishes these results by decreasing resistance in the peripheral vessels, by the removal of the poisons of oxidation, and by mechanically moving the blood-current forward in the lymph-spaces and venous channels; it thus stimulates the circulation, respiration, nutrition, and excretion.

Passive exercise finds the greatest field of usefulness where the nutrition of the part is impaired or destroyed. Muscles can be improved in tone and nutrition, ligaments stretched, the circulation quickened, and overloaded veins made to disgorge their blood. By it the digestive tract may be stimulated to more active habits, and irritated nerves soothed and relieved of their hypersensibility.

The chief forms of passive exercise are three in number, viz.: (1) Massage; (2) vibration; and (3) mechanical manipulation by the machines of Zander and others.

MASSAGE

Massage is the systematic manipulation of the body by the hands in movements of stroking, punching, kneading, and striking. It also includes flexion, extension, and other movements of the joints and limbs, without the coöperation or resistance of the patient. The recognition of this therapeutic agent has been delayed by the failure to distinguish between true massage and unskilled "rubbing," the latter requiring only a certain amount of manual dexterity, muscular strength, and good will. To be a successful operator, one must possess those qualities as a foundation on which to build an intimate and special knowledge of anatomy. The disposition and thickness of muscle groups, their septa, the point where muscle changes to tendon, the situation and course of the veins and arteries, their anastomosis, the location of the nerve-supply, the movements of the limb, and the changes about the joint caused by movement, the situation and extent of the synovial cavities and tendon-sheaths. This knowledge should be practical and continually confirmed or corrected when the parts are active or at rest. In addition to this there must be that touch, firm, insistent, yet gentle, that adapts itself to the hills and hollows of the body surface as if by instinct, and a buoyant constitutional vigor to withstand the exhausting character of its practice.

It is the necessity of those things just enumerated that has limited the practice of true massage to the few who are willing and able to devote the time and study necessary for the thorough acquirement of its technic.

The classification of the movements in massage divides them into four groups (Mezger).

1. **Stroking (effleurage),** in which the hand is passed lightly over the skin, with pressure from the periphery to the center, following the course of the venous circulation and the long direction of the muscles from their insertion to their origin. It may be performed by stroking with the palm of one or both hands, with the thumb or tips of the fingers. The two hands are used upon the large, fleshy parts of the thighs and buttocks, or upon the chest, back, and neck. The thumb is used on small muscles hemmed in by bones, such as the interossei of the hand or foot, or the anterior muscles of the leg. The tips of the fingers are used around the joints of the knee, ankle, elbow, or wrist, the fingers adapting themselves to the shape of the

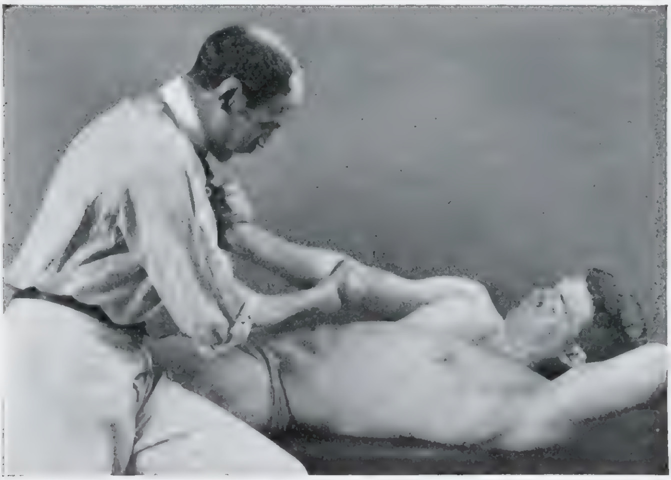


Fig. 2.—Effleurage of the forearm. Note the distention of the veins above the hand that is passing upward.

part worked upon. The strength of the manipulations varies from the slightest touch upon a region sensitive to pressure, to the firm pressure with one hand upon the other, over such large masses as the erector spinæ. Inflammatory products are loosened, passed into the circulation, and rapidly absorbed, while the engorged veins and lymph-channels are unloaded (Fig. 2). This form is the first to be employed in sprains and freshly inflamed synovial membranes, and in all chronic cases where the tissues are matted and sodden, requiring the absorption of an exudate.

2. **Friction,** a firm, deep, circular movement performed by the thumb, tips of the fingers, or by one hand open or clenched. The thumb is employed on the small surfaces of the face or extremities. Friction by the tips of the fingers is used around joints; the fleshy part of the thigh, the arm, and the lumbar region requiring the entire

hand. The friction should proceed in the same general direction as the stroking movements, which should always follow it. The products of fatigue congregating in the deep muscular tissue are thus thrown into the circulation, the gentle manipulations of stroking readily carrying them into the superficial veins. This affects all deeply seated structures embedded in muscular masses, and should be used along the sciatic nerve in the treatment of sciatica and over the abdomen to unload the colon.

3. **Pétrissage, pinching,** or **grasping** is performed by picking up the skin and subcutaneous tissue between the thumb and fingers, and manipulating it with an amount of force not sufficient to cause pain. In this movement the skin moves with the hand of the operator, and the underlying structures are thus massaged by it under the pressure of the fingers. It is most advantageously done by the thumb opposed

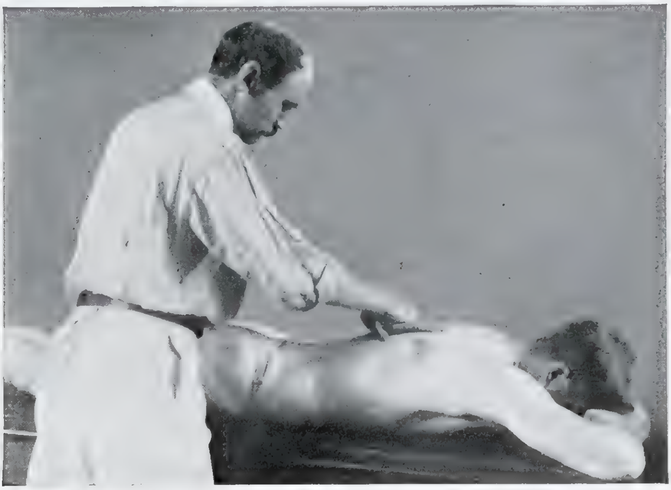


Fig. 3.—Friction of the erector spinæ.

to the first finger, by the fingers opposed to the palm of the hand, or by the two hands opposed to one another. The thumb and fingers are used to reach individual muscles and small groups, such as the muscles of the hand, foot, forearm, and upper arm. The larger muscle masses of the thigh and calf require the use of the fingers opposed to the thumb and hand (Fig. 4), or both hands, the muscle being rolled beneath them and pressed against the bone. This has the same effect as friction on the deep structures, and is better for sensitive, easily irritated surfaces, the skin moving with the hand like a glove. The movement should always be gradual, proceeding from the periphery inward. It is the favorite means used to improve muscular nutrition in conditions of fatigue, in atrophy, in obesity, or other forms of muscular degeneration.

4. **Striking (Tapotement or Percussion)**.—This manipulation

comes under many names, such as clapping, beating, knocking, or hacking. It is done for small surfaces by patting with the open hand, or by slapping with the palm cupped to leave a layer of compressed air between the hand and the surface to be manipulated, a movement

Fig. 4.—Pétrissage of the calf muscles.

that is familiar to every frequenter of the Turkish bath. Its action on the skin, superficial nerves, and vessels is stimulating. Hacking is performed with the ulnar border of the hand, and is used along such nerve-trunks as the sciatic or the spinal nerves (Fig. 5). Where

Fig. 5.—Tapotement of the back with the ulnar surface of the hands.

the bone lies close to the skin, at the ankle- or knee-joints or in manipulations of the scalp, this movement should be performed by the tips of the fingers, but over the fleshy regions of the thigh and buttocks the clenched hand may be used. Each blow stimulates the nerve

powerfully and causes involuntary contraction of the muscle. When the blow is heavy and rapidly repeated, it may even produce local anesthesia. The blows should be quick and sharp, but not strong enough to bruise the muscle and produce after-soreness. It is commonly used in cases of paralysis, neuralgia, and sciatic neuritis.

A fifth manipulation might be added—that of **shaking** or **vibration.** Shaking involves movement of the whole body or region to be treated, while vibration is a lesser motion in which the body or region remains at rest, while the surface and structures immediately beneath it are affected. The term "tremble pressing" accurately describes it. These manipulations are so difficult to perform skilfully and so exhausting to the operator that machines were designed by Zander to replace the inaccurate and rapidly tiring human hand.

General massage is best given at an hour midway between meals, and never immediately after eating. The order in which the manipulations are given is as follows: The parts are first lubricated with cocoa-butter, or, better, dusted with talcum powder, to avoid the irritation which may follow the friction of a hairy surface. The operator starts with the feet. With the thumbs and fingers, the small muscles of the foot are kneaded, special attention being devoted to the interosseous groups, which require slow, deep pressure from the thumbs. Care should be taken to avoid bruising of muscle and skin against the underlying bones. The foot is then grasped and all the natural movements of the toes and ankle are rehearsed. Next the region of the ankle is dealt with in the same fashion, and stroking movements are made from the toes to the leg, to empty the superficial veins of the foot. The leg is next treated by circular friction with the fingers, by deeper grasping of the areolar tissue, and last by industrious and deep pinching of the larger muscular masses, which for this purpose are put in a position of complete relaxation (Fig. 4). For the large muscles of the calf and thigh both hands act, the one contracting while the other lessens its grip. The firm muscles in the front of the leg are rolled under the cushions of the finger-tips. At brief intervals upward stroking is given from ankle to knee, to favor the flow of venous blood-currents. The same process is carried on for the hands and the arms. Especial care is now given to the muscles of the loins, back, and neck, which are subjected to frictions, kneading, and striking with the ulnar border of the open hand (Fig. 5), followed by upward stroking of the loins and back, the same manipulation being directed downward and outward from the head to the shoulders. The abdomen is then treated by pinching the skin and underlying tissue, deeply grasping the entire muscular walls with both hands, pinching and rolling them. Massage of this region concludes with deep kneading by the heel of the hand in a succession of rapid, deep movements passing clockwise in the direction of the colon. The chest is then manipulated upward from the sternum along the line of the pectoral muscles by pinching and kneading of the muscle masses of each side. The face is not usually treated in general massage, but the sides of the

neck are gently stroked from above downward along the course of the internal jugular veins. Each part operated upon should be carefully covered after treatment.

The usual fault in giving massage is that too much is given at one time—Maggiora's experiments prove that the maximum effect on a part is obtained in five minutes. Another mistake is in employing too heavy a hand; a patient should never feel bruised or exhausted, although a pleasant lassitude is one of the most valuable effects.

Massage should be avoided in certain skin affections, as eczema, acne, and other skin eruptions, in wounds, burns, and erysipelas, in tumors and purulent inflammations, and in acute disease of the bone tissue. It should not be used in the acute stages of severe constitutional or local diseases, where complete rest is necessary; and it should be allowed only with great precaution in pregnancy and in the presence of renal disease.

MECHANICAL MEANS

The use of mechanical means for the treatment of disease was first systematized and employed in a complete way by Dr. Gustave Zander, of Stockholm, about 1857. He there established and directed the first Zander institute, and has been actively engaged in the practice of medicomechanical gymnastics, lecturing on the subject at the medical school of Stockholm until his recent retirement, when he was succeeded by his eldest son.

Fig. 6.—Machine for flexion and extension of the forearms.

Zander has devised nearly one hundred machines to give his exercises and manipulations, and his system of mechanotherapy has enjoyed a wide popularity in Europe, and has a considerable following in America. Zander institutes are found in Boston, Baltimore, Philadelphia, St. Louis, San Francisco, and elsewhere, while over seventy sanatoria are supplied with some of his apparatus. The machines are in three series:

First Series.—Apparatus set in motion by the muscular power of the patient.

Second Series.—Apparatus set in motion by means of some motor.

Third Series.—Apparatus exercising, by the weight of the patient's body or by mechanical arrangements, a corrective pressure or tension. They are classified, according to their physiologic effects, into four sections:

1. *Apparatus for Active Movements*.—To exercise and develop —(*a*) Arms; (*b*) legs; (*c*) trunk; and (*d*) balance. These machines are 38 in number. A typical example is Fig. 6, for forearm flexion. Its action may be reversed and used to exercise forearm extension. A number of other machines are made reversible, a necessary economy that is at once apparent.

In the balance machine the patient sits astride a saddle-shaped

Fig. 7.—The "Tower," for respiratory movements. The shoulders are held firmly, while pressure is applied to the back.

seat, grasping a fixed handle-bar. A rolling rotary movement is given the seat by motor power, and to preserve the equilibrium the patient must use all the muscles of the loins and abdomen in turn.

2. *Apparatus for Passive Movements*.—To manipulate the hands and fingers, for chest dilatation, trunk rotation, and pelvis elevation. The machine for chest dilatation merits more than passing notice. It is called the "Tower" (Fig. 7), and the movement is performed by two crutch-like appliances passing beneath the arm-pits, and retracting both shoulders, while the chest is thrust forward rhythmically by a cushion applied against the back of the patient, as shown in the

illustration. The rate is set to correspond with normal respiration, and the thoracic walls are expanded and stretched by its use.

3. *Apparatus for Mechanical Operations, including Vibration, Percussion, Kneading, and Friction.*—Vibration is given to the whole body by the jolting movement of a saddle-shaped seat (Fig. 8), and the Zander vibrator is adjusted to give about 500 strokes a minute to the feet, legs, chest, or abdomen.

Four machines are devoted to percussion: Fig. 9 is provided with four beaters for tapotement along the spine. This machine has been called the "digitalis of the medical gymnast," from its action in slowing the heart-beat.

Fig. 8.—The "horse," to give vibration of the whole body (sitting saddleways).

One machine is devoted to kneading the abdomen and six to friction of the arm, fingers, leg, foot, back, and abdomen.

4. The *orthopedic apparatus* are eleven in number, and are designed for suspension, rotation, and lateral pressure.

A complete outfit requires at least 3000 square feet of space, with consulting and resting rooms, and a gas engine or other motor.

Many objections to the use of duplicate movements may be overcome by employing these machines; the amount of resistance is always constant, and can be diminished or increased as desired, according to the strength of the patient. The dose can be accurately prescribed, and the uncertainty of the human hand, governed as it must be by the operator's physical condition, can be eliminated. The amount of resistance forms a curve, the apex of which is at the

point of greatest physiologic efficiency, thus making it more scientific in its application than the varying hand of the operator.

A number of similar machines were designed by C. F. Taylor

Fig. 9.—Zander's back percussor.

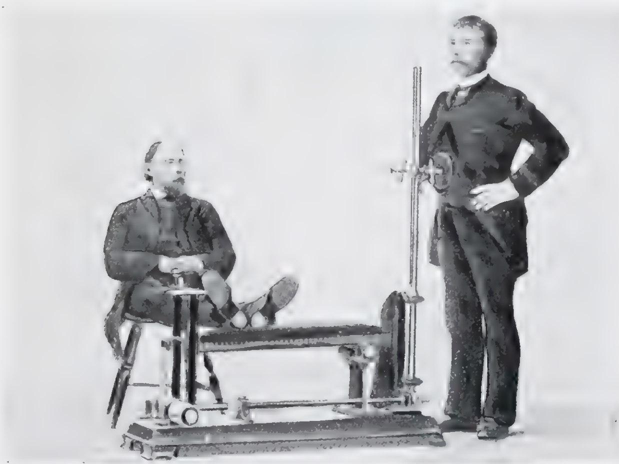


Fig. 10.—The Zander vibrator.

(1869), and numerous modifications have been made to simplify the somewhat cumbersome mechanism of the originals.

The Zander vibrator, which is the mechanical means of giving the movements of shaking or "tremble pressing," described under the manipulations of massage, gives a rate of from 500 to 900 strokes to the minute, but more recent machines carry the rate as high as 2000 to 5000 strokes.

There are three types of vibrator now in use: the rigid arm vibrator, of which the Zander machine is an example; the flexible shaft vibrator, and the portable vibrator, attachable to an electric-light plug.

A good machine should be readily adjustable in rate and length of stroke, and should be capable of giving percussion and a rotary, boring motion.

The power of properly applied vibratory movements to quiet

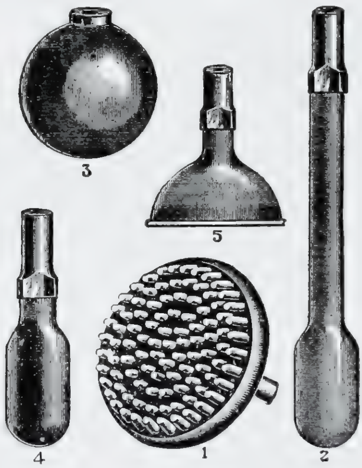


Fig. 11.—Various attachments recommended for use in the application of mechanical vibratory stimulation to the various organs and cavities of the body (Pilgrim): 1, Rubber brush; 2, rectal and vaginal attachment (rubber); 3, rubber ball; 4, throat attachment (rubber); 5, eye-cup (rubber).

pain, to make a rapid and excited heart beat slow and steady, and to reach, through the spinal nerves, the deep-seated organs presided over by the sympathetic nervous system, is well established.

Three points must be carefully considered in the application of this treatment: (1) The length of the stroke; (2) its rate; (3) the amount of pressure. All three can be varied within very wide limits, and modified in their effects by the applicator used, the chief attachments for a well-designed machine being a rubber brush, a ball of hard rubber, and a second ball of soft rubber for the throat and for the large muscle masses, like the erector spinæ; a hollow rubber ball for the treatment of the eye; a flat disc, a vacuum cup, and special vibratodes of hard and soft rubber for rectum and vagina. The late Maurice F. Pilgrim, in his little work on vibratory stimulation,

classifies the movements into: (1) Stimulation; (2) vibratory stimulation; and (3) vibration.

Stimulation is produced by a medium stroke and light pressure, with the brush attachment, for increasing the blood-supply to a region, improving its nutrition and tone. To produce mild stimulation, an application should last from three to seven seconds.

Vibratory stimulation is applied by the rubber ball with a medium stroke and deep pressure, the treatment lasting from eight to twelve seconds over one spot. This is recommended for cases in which the viscera are to be reached by acting on the spinal nerve-roots.

Vibration is produced by a heavy stroke and deep pressure with the hard-ball attachment. It should not be given for more than fifteen or twenty seconds, and is used to inhibit a nerve that is giving pain. Overstimulation, while not permanently harmful, is never desirable.

Case reports show the usefulness of the Zander machine and the more modern vibrators in the many conditions where this form of massage can be employed. Their accuracy and control, compared with the administration of friction and vibration by the hand, need not be dwelt upon.

PHYSIOLOGY OF EXERCISE

The effects of the three kinds of exercise described on the structure and behavior of the muscle vary widely. Single and complete contraction, however mild the resistance, improves the nutrition if frequently repeated, as shown by an increase in size and efficiency. When, however, the tension is habitually excessive, minute ruptures occur in its substance and sheath, fibrous deposits are formed, and the muscle itself becomes shortened, hard, and inelastic.

The number of muscles involved in a simple movement multiplies with the intensity of the effort. The trial of grasping power by the hand dynamometer is designed to test the flexors of the hand and forearm, but in the strife for additional force, muscular contraction spreads to the arm and shoulder and throughout the entire muscular system until its intensity is expressed by the face. If, however, skill is an important factor in the exercise, the emphasis on alacrity and accurate control cultivates in the muscle economy of effort and promptness in responding to the will. In other words, the latent period is shortened.

In exercises of endurance each movement is comparatively mild, and there is less tendency to shortening and stiffening of the muscle so frequently found after extreme effort. Development is general rather than local, and long distance runners are not noted for the thickness of their calves.

The element of skill does not play an important part in such habitual or automatic movements as walking or running, so that their value in its promotion is comparatively slight, but general nutrition is best improved by the rhythmic self-massage of repeated movement.

Passive exercise improves the nourishment of the muscle-cell by forcing out the products of fatigue and keeping it bathed in a constantly renewed stream of arterial blood. This alone is sufficient to prevent wasting of substance in conditions where active movements are impossible, but it has little power to modify muscular strength or control.

When exercise is sufficiently active, a larger blood-supply is required and its purification must be thorough. The rate of the heart-beat and of the breathing is accelerated, the heart driving the blood into the arteries with a more powerful stroke. The respiratory center is stimulated to increased activity by the circulation of lactic acid and acid phosphates in the blood as a result of muscular contraction.

An additional amount of CO_2 can be eliminated by using a larger surface of the lung tissue than is employed in ordinary life, without any great increase in the rate of breathing. Increased power of elimination can thus be acquired by practising movements of artificial or forced respiration which strengthen the accessory breathing muscles of the chest and stretch the thoracic cavity. It is, however, only with greater respiratory need that increased absorption of oxygen takes place. To produce all the conditions necessary for an increase of respiratory power, active exercises causing actual tissue waste are thus required.

If the amount of muscular work be increased beyond the rate of elimination, acute general fatigue or breathlessness is inevitable. It is characterized by rapid, shallow breathing, a sort of respiratory madness, a fluttering pulse, and such symptoms as singing in the ears, dizziness, and a feeling of suffocation, while accompanying the thirst for air are mental anxiety, confusion, and even unconsciousness.

This physical distress is preceded by a period of stimulation in which the eye becomes bright, the skin flushed, and a warm glow is felt from the dilatation of the capillaries. This dilatation of the capillaries is a sign of the increased power of the heart-beat, which exalts the tension throughout the whole arterial system and drives the blood with quickened stream through vessels which at rest are almost empty.

In exercise of effort or speed, such as lifting a heavy weight, wrestling, throwing the hammer, or sprinting, the muscles of the chest-wall that assist in supporting the arm and shoulder come into energetic contraction, pressing on the elastic cushion of the lungs, so as to give the arm muscles a firm base of action. The teeth are clenched and the larynx is closed, corking up the air in the lungs, where it is still further compressed by the contraction of the abdominal muscles. Violent pressure on the thoracic contents is thus produced, and the ventricles of the heart empty more quickly and completely than is their habit. This is especially true of the left ventricle and the aorta. The coronary arteries, which give nourishment to the

heart, are compressed, and the circulation of the heart-muscle partially arrested, while the refilling of the thin-walled auricles is hindered. The blood in the arterial system is dammed back by the resistance in the engorged veins, and the superficial veins of the neck, temples, and forehead swell up like cords, and the complexion becomes first red and then dusky.

The blood-pressure mounted to over 200 mm. in a series of experiments by McCurdy* in a back and leg lift in which the effort was maximum, but the blood-pressure fell at once when the obstruction to the return flow was removed, equilibrium in the circulation being rapidly established, and little acceleration of the pulse-rate being noted, the disturbance above described varying directly with the severity and length of the effort. We find then the greatest strain on the heart and blood-vessels in exercises of strength and speed, more especially in all feats where the arms are used to lift or pull great weights or to support the body, these movements involving as they do fixation of the chest-walls.

From the above it will be clear that exercises requiring sudden and great muscular effort should be used with caution in those whose arteries have lost the first resiliency of youth, for in them damage may easily occur, although in youth no voluntary effort can be violent enough to burst a healthy vessel. Such exercises are a test of their quality rather than a means of systematically developing them, and no system of physical education composed exclusively of such exercises can lay just claim to completeness.

It is to exercises of endurance that we must look for the systematic development of strength and resistance in the heart and arteries. In mild, rhythmic movements the blood-pressure and temperature rise gradually and never attain a great height. They remain high after the exercise is finished, and then drop to subnormal much more slowly than the pulse-rate. The pulse-rate rises abruptly, remains high, and drops suddenly at the end of the exercise. During this period the circulation is carried on with increased force and rapidity, but without great overstrain.

"Athletic training is mainly heart training."† Exercises of endurance distribute the activity widely, and gradually approach the maximum without interfering mechanically with the respiratory movements. They do not require supreme efforts, but they accelerate the activity of the heart and lungs, at least so long as the exercise lasts. The aggregate of work done is very much greater than in exercises of strength. Such exercises must, however, be active enough to provide for the free circulation of the lymph, which is carried on mainly by the massage of muscular contraction. If a walk be listless enough, there may not be sufficient movement of the muscles to thwart the pernicious influence of gravity acting on the column of blood contained in the veins of the belly, thighs, and legs,

* Amer. Jour. Physiol., March 1, 1901.

† Roy and Adami, Brit. Med. and Surg. Jour., 1888, No. 1459.

and the vessel-walls may finally become permanently stretched and varicose.

Massage mechanically excites the vessels to action, empties the lymph-spaces, and hastens the circulation. It usually raises the general body temperature* as well as the part manipulated, and through these means it removes fatigue products, increasing the muscle irritability lost from overwork or disease.

Many movements may be chosen because of the automatic massage given to the larger vessels by the action of the limbs as well as the muscles. Eversion and extension of the thigh stretch the deep fascia and press on the crural vein underlying it. If the thigh be turned inward and flexed, the fascia relaxes, drawing the vein wall connected with it upward, and thus mechanically enlarging it. If the thigh be now completely flexed and inverted, pressure is again exerted on the vein. The rhythmic repetition of these motions of the thigh pumps the blood toward the heart, the valves of the veins allowing it to flow in that direction only. This process is continually at work in such movements as climbing, rowing, sliding, skating, and swimming.

The muscles are the slaves of the nerve-centers, and in fatigue the will tires long before the contracting power of the muscle is lost, for if the motor nerve to the fatigued muscle be cut, feeble contractions can be strengthened by artificial impulses of electricity.

Fundamental movements, such as breathing, eating, speaking, and walking, become, through constant repetition, automatic early in development, and the management of them is turned over to lower centers in the hind brain and cord, so that the motor area of the highly developed cortex may be devoted to those accessory co-ordinations that are never automatic and need long training to become habitual.

The acquirement of skill is, then, more a training of the nerve than of the muscle, if it is at all permissible to speak of them separately in this connection.

The simplest movement means not only a nerve impulse to the acting muscle, but a wave of impulses to the accessory and antagonistic groups which must control and steady the movement. If the movement is unfamiliar, this contraction will be jerky and inaccurate instead of unerring and graceful, or, in other words, physiologically economical. Many useless muscles will be employed, and the expense in nervous energy will be out of proportion to the result. The first attempt at comparatively simple actions rapidly exhausts the attention. The apparently aimless and uncertain movements of a child learning to walk illustrate the amount of concentration at first required in what afterward becomes automatic.

Exercises of skill cultivate habits of economy in the expenditure of nerve force, and we instinctively admire a difficult exercise performed with thrifty ease just as we unconsciously censure the nervous

* Weir Mitchell, Fat and Blood.

prodigality of the unskilful tyro. The distracting influence of mental excitement or worry is seen in the broken shoe-lace of the hurried man and the failure of the nervous pianist before a critical audience.

When a certain degree of skill or coördination is learned, the interest passes on to what is more difficult, and this is one reason why any course in physical training should begin with simple and easily learned coördinations, progressing to those more difficult and complicated feats that serve to keep alive the attention and interest of the pupils.

Exercises of strength and skill train that alertness of mind so necessary in ordinary life. They shorten the period between thought and action, and give that condition known as "presence of mind." This cannot be done without a corresponding mental strain. The man who is held alert too long on the starting line before a race, tense and straining for the signal, finds such a rapid exhaustion of his powers of concentration that in a second or two the strain becomes intolerable.

Exercises of endurance, which are simple, habitual, or even automatic, do not require great nervous concentration. A man can walk or run and have his mind on other things, but when they are carried to the point of acute fatigue, the phenomenon of breathlessness, already described, takes place.

Repeated attacks of fatigue produce that chronic poisoning known as *staleness* or *overtraining*, which is, above all, a slow poisoning of the nervous system, just as subacute fatigue was a general intoxication by the products of muscle waste, and acute fatigue, an intoxication of the breathing apparatus.

The rôle of passive exercise is one of relief to the nervous system, for the nutrition of muscles may be maintained without the expense of nervous force required to make them contract, and massage acts on the central system through the nerves of sense, stimulating or soothing, according to the nature and amount of the manipulation.

The absorption of carbohydrates and proteins by muscular action causes a hunger for food, just as the using of oxygen produces a hunger for air. With the supply of food the muscles increase in size and strength, and the amount remaining unused is excreted or stored up in the tissues as fat. If training be severe, this natural horde of fat is speedily expended, and a man in fine athletic condition is always below his normal in fatty tissue. Athletic training aims to produce a *machine* to run, leap, fight, or row, and fat would only be an encumbrance, so that a man in fine athletic form would not be in the best condition to resist the siege of an exhausting infection, like typhoid fever or pneumonia, where the stored-up fat of the normal individual becomes his most valuable asset. The loss of weight during athletic exercise may be from five to eight pounds in less than half an hour, a loss which is continued after exercise is stopped if no food or drink is taken. This weight is regained by eating and drinking within

twelve hours, and failure to thus regain it is always considered as a sign of the near approach of exhaustion.

During prolonged and severe exercise there is always a rise of temperature of 2 or 3 degrees (taken per rectum).

The fever is accompanied by nephritis lasting several days, seen in the presence of albuminous urine containing casts and often blood.

This albuminuria may persist for several weeks after a severe muscular test like a 20-mile run, but complete recovery is practically universal.

THE APPLICATION OF EXERCISE TO PATHOLOGIC CONDITIONS

The efficacy of both active and passive exercises in the treatment of pathologic conditions depends on their power to change anatomic structure and to stimulate physiologic function. This anatomic and physiologic effect is very differently expressed in feats of strength and skill, in exploits of endurance, and in the passive procedures of manipulation and massage.

Exercises of strength, requiring little coördination, rapidly add to the bulk of the muscle tissue, but it is the nervous system that receives the accurate training in exercises of skill, the muscle girth being increased but slightly; while mild automatic exercises of endurance train the heart and expand the lungs more surely than do supreme efforts of strength or the cultivation of skilful muscular control.

Passive exercise has an almost purely mechanical effect on the muscle tissue and circulation obtained without mental concentration or the taxing of the heart and lungs.

Sprains.—In a sprained or disabled joint the circulation is subnormal and the process of repair is delayed on account of the enforced immobility of a structure whose natural function is movement. Massage is the most valuable means of hastening recovery in such cases. In an old sprain the tissues are matted together; the surface of the skin is dry and harsh, bluish, livid, and shrunken in appearance. The stagnant blood circulating slowly through the obstructed and narrowed vessels is unable to give the tissues sufficient nutrition or to remove the accumulated débris of a month's inaction. Manipulation and massage act upon the muscles, nerves, blood-vessels, and skin, and the circulation at once renews its power. The veins and absorbents are emptied first, and the fluid contained is driven on toward the heart; the pressure falls in the smaller vessels and tiny irregular lymph-spaces, extending through the tissues in all directions. Their contents are driven into the emptied veins, the circulation becomes more rapid, the tissues become full and sensitive to the touch, and the parts regain the even, rounded contour of active health. The skin loses its harshness, becoming soft and pliable, and after a single application the muscles are capable of working with less fatigue, while the joint becomes pliant and the ligaments relaxed.

Adhesions are permanently stretched or broken down, and the encumbering waste materials thrown into the circulation, while the effect upon the nervous system is indicated by the disappearance of the pain and sense of insecurity.

The swelling and tension so characteristic of a recent sprain can be quickly absorbed by gentle and careful massage, accompanied by elastic pressure and the application of heat between the treatments. The tension disappears as the fluid is carried off, the temperature falls, and the pain caused by pressure on the sensory nerves is relieved. Extravasated blood is broken up, and the adhesions usually found between torn and mangled surfaces are prevented, although time is always needed firmly to repair structures that have been actually lacerated.

If the sprain be recent, adhesions are prevented altogether, but if they have already formed, they may be stretched slowly and gradually by repeated gentle movements or may be actually torn. Few minor operations give such instantaneous and striking relief when used with care and judgment. These movements stretch or snap small adhesions that limit the excursion of the joint or press upon nerve-endings, causing acute pain. It is in these manipulations that bone-setters have acquired their reputation for supernatural skill, and many miraculous instances are recorded of the immediate recovery of long disabled joints. The joint that has remained for weeks cold and inactive, incapable of performing its proper movements, the seat of constant wearing pain, recovers its flexibility, loses its pain, and allows itself to be handled and used with freedom. After perfect freedom of movement has been obtained, the voluntary power is sometimes slow in returning and the recovery must be completed by active voluntary exercise in accordance with the natural movements of the joint.

Postural Defects

A muscle that is repeatedly exercised in movements of full contraction against resistance gradually pulls its origin and insertion nearer by its inherent elasticity, even when at rest. It is this quality that is of assistance in the treatment of the many faults of posture caused by the overstretching of weakened muscles and ligaments, and the consequent overdevelopment and shortening of their antagonists.

The whole struggle of man is to establish and maintain the upright posture by the extension of the body, and to do this he must overcome the constant tendency to flexion caused by the force of gravity and occupation, for the entire range of postural defects, such as flat-foot, round shoulders, flat chest, irregular development, and fatigue scoliosis, are essentially *occupation disorders*, associated with the maintenance of the erect position, first, of the muscular system; second, of the ligaments; and, finally, in severe cases, of the bones themselves. These defects are caused most frequently by long-

continued faulty positions in the growing child, and it is to the development of the weakened and overstrained muscles, to the stretching of contracted ligaments, and to the reëducation of proper sitting and standing positions, that we must look for the greatest curative effects in these disorders.

Exercises of strength are to be chosen for the correction of postural faults, and their selection must be carefully made, for the weakened groups must be isolated for action, so that general fatigue may not supervene before the full therapeutic effect is obtained.

The structures concerned in the maintenance of the upright posture may yield at the spine, which becomes bent and twisted, at the knee-joints, and at the arches of the feet, causing the deformity known as pes planus, or flat-foot.

Flat-foot.—The bony structure of the foot is arranged in the form of two arches, anteroposterior and lateral. The anteroposterior arch (Fig. 12) is formed by the os calcis, the scaphoid, the three cuneiform bones, and the metatarsals, with the astragalus as a key-

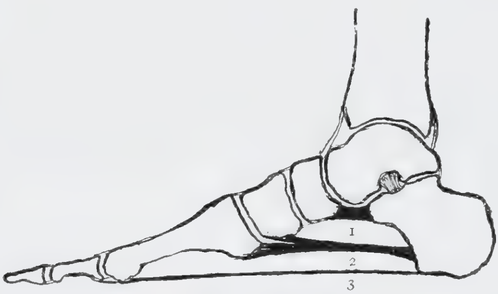


Fig. 12.—Anteroposterior arch: 1, Short plantar ligament; 2, long plantar ligament; 3, plantar fascia.

stone. It is supported by the ligaments extending between the adjacent bones like ties, but more especially by the short plantar ligament (Fig. 12, 1) binding from the os calcis to the navicular. This powerful ligament completes the socket formed by the navicular and the os calcis, into which fits the head of the astragalus, or keystone of the arch. The other main ligament of support is the long plantar (Fig. 12, 2), which extends from the body of the os calcis to the proximal, and indirectly to the distal, end of the metatarsal bones, through its connection with the tendon-sheaths. These may be termed the first line of defense in preserving the anteroposterior arch.

The second line of defense consists in some of the short muscles of the foot,—the flexor brevis digitorum (Fig. 13, 3) and the flexor brevis hallucis (Fig. 15, 3),—assisted by the tendons of the flexor longus hallucis (Fig. 13, 4), the flexor longus digitorum (Fig. 14, 4), and of the tibialis posticus, passing around the inner malleolus, and binding together by its expanded tendon all the bones of the tarsus except the astragalus. The tibialis anticus (Fig. 16, 1) also helps

by lifting the proximal end of the first metatarsal bone. These muscles, by their action, all tend to lift the inner side of the foot and draw together the limbs of the anteroposterior arch, like the string of a bow.

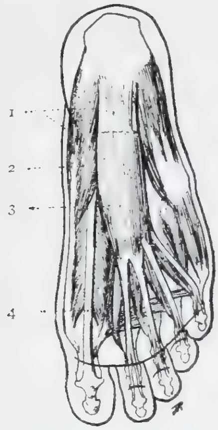


Fig. 13.—The superficial muscles of the foot: 1, Abductor minimi digiti; 2, abductor hallucis; 3, flexor brevis digitorum; 4, tendon of flexor longus hallucis (Richer).

Fig. 14.—Second layer of muscles of foot: 1, Tendon of flexor longus hallucis; 2, tendon of peroneus longus; 3, accessorius; 4, tendon of the flexor longus digitorum and lumbricales; 5, flexor brevis minimi digiti (Richer).

Fig. 15.—Deep layer of muscles of the foot: 1, Peroneus longus; 2, interossei; 3, flexor brevis hallucis; 4, 5, adductor hallucis (Richer).

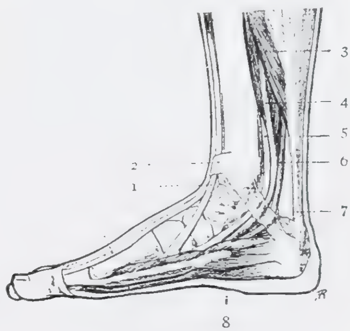


Fig. 16.—The tendons that support the arch: 1, Tibialis anticus passing under annular ligament (2); 3, soleus; 4, flexor longus digitorum; 5, tibialis posticus; 6, flexor longus hallucis; 7, tendo Achilles; 8, abductor hallucis (Richer).

The lateral arch of the foot (Fig. 17) is imperfect, in that its support is at the outer side only, the weight being borne by the os calcis, the cuboid, and the fifth metatarsal. The arch rises upward

and inward, and its free, unsupported edge is represented by the astragalus, the navicular, the internal cuneiform, and the first metatarsal. The lateral arch is supported principally by the tendon of the peroneus longus (Fig. 15, 1; 14, 2), crossing the foot diagonally from the cuboid to the internal cuneiform, and by the ligaments binding together the adjacent bones; it also receives some support from the tibialis anticus.

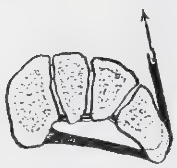


Fig. 17.—Lateral arch. Pull of peroneus longus.

The body weight is transmitted through the tibia to the astragalus. This pressure on the keystone tends to spread the members of the arch, and, in so doing, to stretch the long and short plantar ligaments. As the structures yield the inner side of the foot comes down, and the lateral arch shares in the flattening process. It is, however, the unsupported part of the arch that is chiefly affected, and the flattened instep also projects inward, causing the inner line of the foot to bulge at its center, the outline becoming convex instead of straight or concave. Pressure is

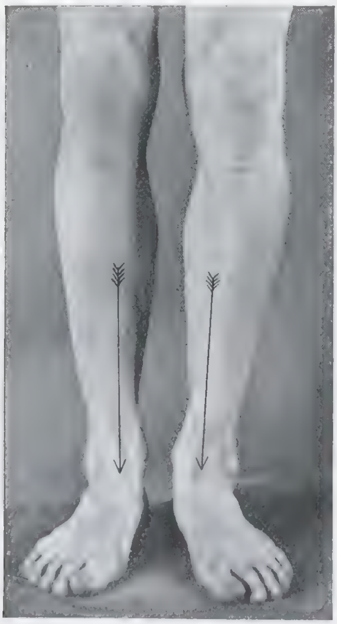


Fig. 18.—Direction of the body weight on the unsupported part of the lateral arch.

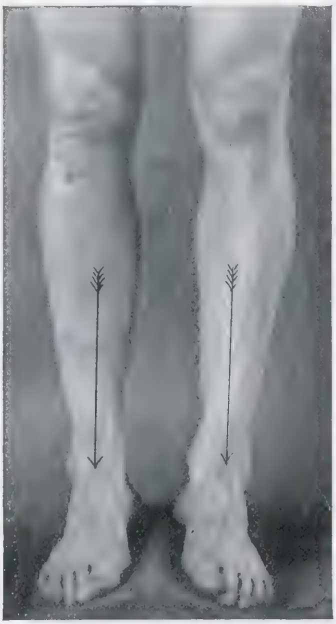


Fig. 19.—Transferring the direction of the body weight to the outer side, or supported part of the arch, by raising the inner side of the shoe.

thus put on surfaces of the bone that are not accustomed to it, and severe crippling pain is one of the most common results, while corns and callosities add their discomfort to the unnatural pressure and friction of the abnormal position.

A typical case of flat-foot would then show a turning-out of the line of the heel, a convexity of the inner contour of the foot, and a concavity of its outer margin. A tracing of the foot would show no instep (Fig. 21). While this deformity is sometimes caused by paralysis of the posterior tibial or peroneal group of muscles and by traumatism, still the great majority of cases are what might be termed static, and are found in nurses, clerks, waiters, barbers, motormen, and all others whose long hours of continual standing keep the muscles and ligaments of the foot constantly upon the strain. It is also frequently found in the very fat, whose excessive weight is too much for their ligaments.

Fig. 20.—Flat-foot (Fowler).

A considerable degree of flat-foot may be present without causing much irritation, and again great pain may be caused by comparatively slight degree. Painful points should be sought for at the calcaneonavicular ligament, the anterior end of the os calcis, at the attachment of the short plantar ligament, and at the base of the first metatarsal, while shooting pains up the calf of the leg are frequent. The heels, as seen from the back, are characteristic, the line of the tendo Achilles, with the ball of the heel, usually making a sharp turn outward (Fig. 22). This is emphasized when the weight is borne on the foot. It may very often be detected by examining the shoe only, the flat-footed patient tending to wear down the inner side of the heel and sole.

Fig. 21.—Print of a normal foot-sole (A) and of a flat-foot sole (B) (Albert).

A patient should be examined with the foot uncovered, walking backward and forward in order that the foot may be seen in action from all positions. The inner line of the foot, and the extent to which the instep is destroyed, should be noted.

The appearance of the foot is not the only thing to be considered, for the arch of a baby's foot has an appearance of flatness, because the pad of fat which occupies the arch is not absorbed until the child has begun to walk.

Flat-foot is liable to be confused with tenosynovitis, the pains from corns and callosities, and with neuralgia of the metatarsus or the tendo Achilles. The most frequent mistake in diagnosis is rheumatism, which seldom affects the foot alone, although I have

seen it in one case in which the diagnosis of rheumatism was confirmed by its subsequent appearance in other joints.

It is the cause of great pain and discomfort, and sometimes the patient becomes chair or bedridden.

Treatment.—No treatment is complete which does not develop the structures involved in the normal preservation of the arch.

The market is flooded with patent devices for the support of the broken-down arch, but no mechanical treatment should be employed unless it accurately fits the particular case. More harm than good has been done by the use of ill-fitting and imperfectly supporting foot-plates. A foot-plate or bandage of any kind must be looked upon in the light of a splint, to be discontinued as soon as possible, and to be used only in conjunction with other means of treatment.

Fig. 22.—Showing one of the first signs of flat-foot. The outward deflection of the lower end of the tendo Achilles when weight is put on the foot (E. H. Ochsner).

In most cases treatment by exercise should be begun by manipulation, stretching and massaging the foot; but where the pain is too severe, it may be necessary to give the foot a complete rest for two weeks or more by incasing it in a plaster bandage. When tenderness is sufficiently lessened, the following manipulations and active exercises may be started:

Exercise I.—Patient sitting, leg extended and supported just above the ankle. Grasp the right foot just above the ankle with the left hand. Place the right hand on the sole of the foot. With the thumb pointing toward the toes grasp the foot firmly, circumduct the foot slowly in the following order: (1) Extension; (2) inversion; (3) flexion; (4) eversion. This should be done with as much force as can be used without producing pain, and repeated up to about thirty times. Each part of the movement should be separated from the next by a distinct pause. When this has been learned, it may be replaced by the active movement.

Exercise II.—Foot in the same position. Circumduction in the same order without assistance. Repeat fifty times.

The operator should supervise this movement and encourage the patient to make the extension and inversion as complete as possible, so that the long and short flexors and tibial muscles may have complete contractions at each movement (Figs. 23–26).

Exercise III.—Patient standing with toes in and heels out, and about twelve inches apart (Fig. 27). Rise on the toes and press out slowly (Fig. 28). Repeat fifty times.

Exercise IV.—Patient standing, feet parallel and six inches apart. Raise the inner side of the foot, throwing the weight on the outer border. Repeat fifty times.

This transfers the weight from the ligamentous support to the bony ridge of the outer edge of the foot (see Figs. 18 and 19) and should be followed by—

Exercise V.—Patient standing, feet parallel, weight resting on the outer side of the foot (Fig. 29). Walk forward and backward fifty steps, keeping the feet parallel.

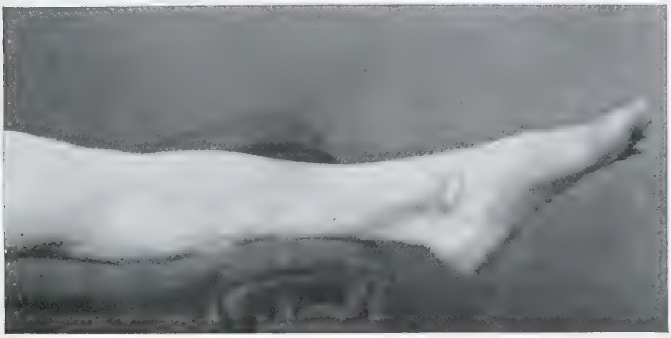


Fig. 23.—Extension of the foot.

This exercise is also valuable in throwing the weight of the body on the solid part of the lateral arch, and is one that is often instinctively taken by patients to relieve the intolerable pain caused by the overstretching of the ligaments.

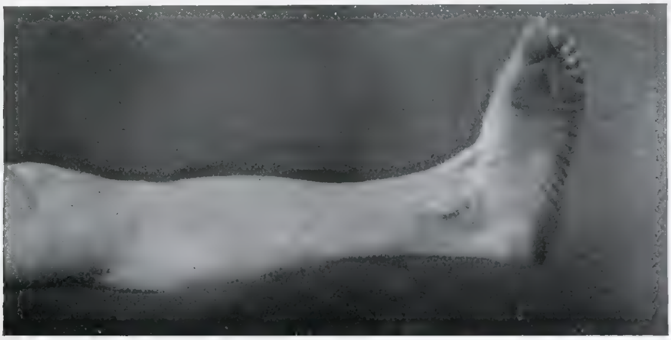


Fig. 24.—Inversion of the foot.

Exercise VI.—Raise the heel one inch from the ground and walk without bringing the heel down at all, as if the heel were painful.

This exercise may be practised indefinitely, the patient walking for 100 yards without letting down the right heel, and then the next 100 yards without letting down the left, or raising the heels when

crossing the street, or other plans that will readily suggest themselves. A little practice will enable him to walk in this way without limping or otherwise attracting attention.

These exercises should be repeated daily, and in slight cases should be carried on for at least three months, whereas in severe cases it should be kept up as a daily routine for at least one year.

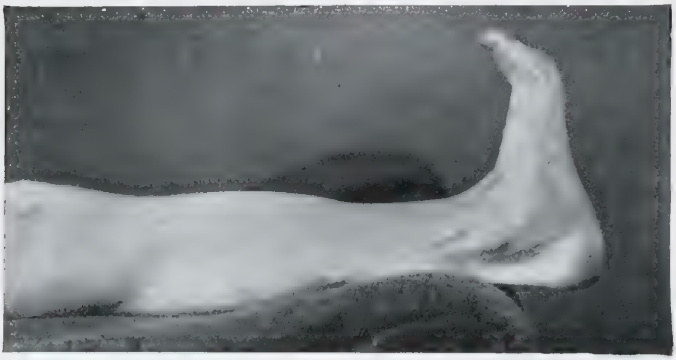


Fig. 25.—Flexion of the foot.

In favorable cases this may be all that is required (Figs. 30–33), but usually it will have to be combined with some form of specially designed shoe, with strapping or other mechanical support to retain the gain and to prevent the original cause of the deformity from undoing the corrective work of the exercises.

A flat-foot plate or bandage must, as already emphasized, be

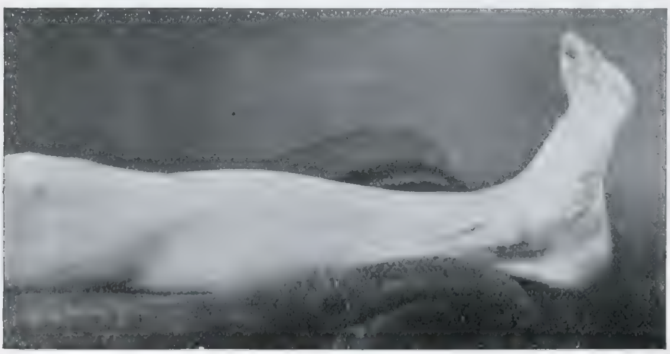


Fig. 26.—Eversion of the foot.

regarded in the same light as a crutch or cane would be for a joint unable to bear the strain of use, and it is to be discarded when the normal strength has returned and undue irritability has disappeared.

To continue the support after the indications for its use have disappeared is to hamper the normal functioning of the muscles and ligaments of the foot and leg.

Round Shoulders.—If an infant be placed upon its back, it will lie with a straight spine and thighs flexed to nearly 90 degrees. If it be placed in a sitting posture, the thighs remain flexed, but the spine shows a single convex backward curve, involving its entire length, but with the assumption of the standing posture, the right angle between the trunk and thighs must be extended to a straight line, and this is effected by a compromise between the lumbar spine and the hip-joint, both yielding part of the way.

When the hip-joint is extended, the iliopsoas muscle is stretched, though this extension is not sufficient to preserve the straight spine of the sitting posture. A sharp, forward curve develops in the lumbar region. The anterior vertebral ligaments are stretched, the inter-

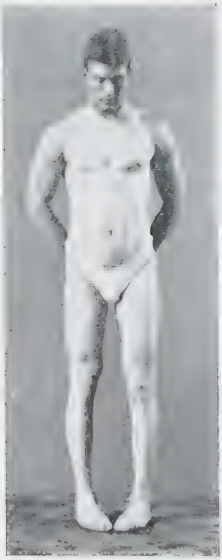


Fig. 27.—Standing with toes in and heels out.

Fig. 28.—Rise on toes and press out slowly.

Fig. 29.—Walking on the outer sides of the feet.

vertebral discs thicken anteriorly, and the erector spinæ muscle becomes active and powerful. This curve, which is very marked in young children, gives them their characteristic "pot-bellied" appearance, and is accompanied by a localization of the compensating backward curve to the dorsal region, and by the formation of a third in the cervical region, showing the same forward convexity as the lumbar curve. These three curves are physiologic, and are always found in the adult normal spine, and it is their exaggeration or imperfect development that will be next considered.

The shoulder girdle is constructed to permit the widest range of movement with the utmost lightness of structure, but the pelvic girdle, whose chief office is that of support, is firm and arch-like, with powerful ligaments, heavy bones, and scarcely perceptible

movement, while the entire weight of the head, neck, upper extremities, and shoulders hangs upon the flexible and growing spine during the

Fig. 30.—M. March 6th.

Fig. 31.—M. April 3d. After one month's exercise only.

standing and sitting positions. The muscles that steady the spinal column rapidly become fatigued when thus kept on the strain, and

Fig. 32.—A. M. November 4th. Before beginning treatment.

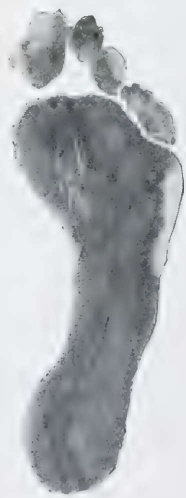


Fig. 33.—A. M. March 10th. After exercise treatment for five months.

allow the shoulders to droop forward, bending the neck and back with them.

In the normal standing position a plumb-line will touch the sacrum

and the dorsal spine at their greatest projection. The attitude can be better recorded, however, by Lovett's device, in which the relation of certain points on the skeleton to a perpendicular line dropped to the external malleolus is graphically shown, the marked points being the mastoid process, the vertebra prominens, the seventh dorsal spine, the fourth lumbar spine, the great trochanter, and the head of the fibula.

A composite of 72 normal boys (Greenwood) between the ages of fifteen and nineteen years shows the following tracing (Fig. 35).

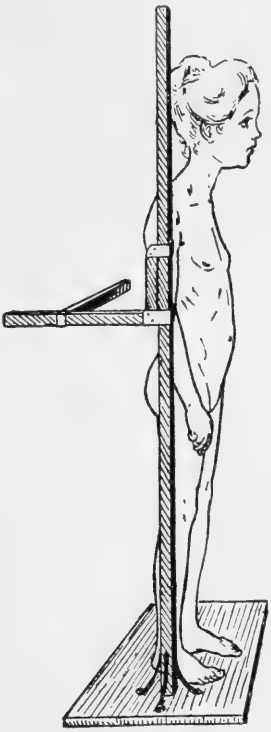


Fig. 34.—Lovett's apparatus for measuring variations from normal attitude in the anteroposterior plane. The bar is six inches behind the external malleolus.

Fig. 35. — Composite curve of 72 normal boys (Greenwood).

Fig. 36. — Curve of young adult female of good carriage (Lovett).

By means of this standard faulty attitudes may be divided into—(1) Round back, showing a general curve backward, with little lordosis. (2) Round hollow back, with the backward projection greatest in the middorsal region, and with pronounced lordosis, the forward projection of the head bringing the upper three measurements almost in line. (3) Forward displacement of the shoulders, the scapulæ and clavicles being displaced independently of the condition of the spine.

This condition may exist either with or without a rounded back. A graphic tracing of these curves may also be obtained by the pantograph (Fig. 37).

From the standpoint of treatment these deformities may be classified into flexible and resistant.

During the years of growth posture will usually take care of itself if constant change be allowed, for change is instinctive and automatic in the child, and his varied activities may be trusted to lead him along normal lines. If, from inherent weakness or the confinement of school life without the relief of games and play, this normal development be hindered, the spine is one of the first parts of the body to reveal it.

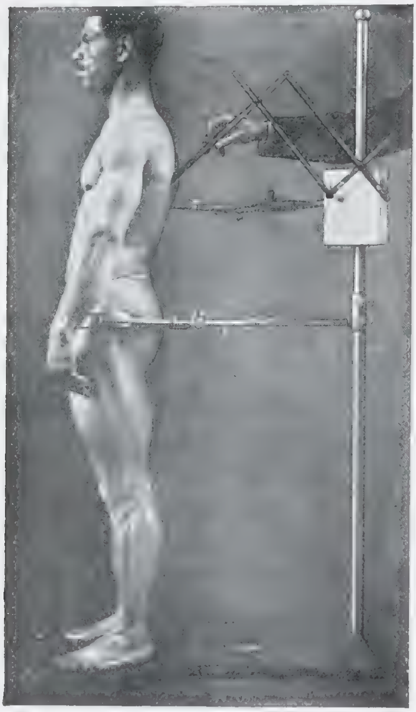


Fig. 37.—Making a tracing of the anteroposterior curves of the spine by the pantograph method.

The causes of round shoulders are, then, those general conditions that produce muscular or constitutional weakness, like rapid growth, overwork, bad air in schools or home, acute illness, myopia uncorrected by glasses, poor hygiene at home or general lack of exercise, and, secondly, occupations that demand long-continued flexion during the period of growth. Among these may be mentioned the use of ill-fitting school furniture, long-continued writing and drafting or work with the microscope; in fact, the requirement of any fixed position for more than a few minutes at a time in a young child. The third cause, more direct than either of the others, is the wearing of clothing supported by suspenders bearing on the points of the shoulders, tending to pull them downward and forward or even to produce a painful deformity of the scapula.

An examination of the back should begin by testing the spine's range of movement, forward, backward, and lateral. The patient should then take his habitual standing position, which he should retain until his self-consciousness abates. The overcorrected standing posture should then be tried. This may be done by having him force the chest forward and upward to touch the surgeon's hand, held just far enough in front of and parallel to the chest-wall to bring the contour of the thorax directly above that of the abdomen. This

manœuver should always be done before a mirror, that the patient may associate the sensation with the picture of the correct posture, and it will take time and patience on the part of both. He should then be taught to take several long breaths without relaxing the pose. If the child be placed face downward, with the arms at right angles to the body, flexibility of the shoulders can be tested by attempting to force them back of the middle line of the body. They should then be lifted upward beside the head and forced backward. During these movements the whole spine should be narrowly observed, as in resistant cases the arms cannot be brought behind or even up to the median plane of the body. It can only be simulated by hollowing the lower part of the back and protruding the abdomen, flattening the chest, and projecting the chin. In non-resistant cases there is usually a general relaxation of the ligaments, as shown in hyperextension of the elbows and knees, as well as of the spinal ligaments, and if the patient can voluntarily assume a correct position, the case may be pronounced non-resistant. In resistant round shoulders and forward displacement, however, there is always more or less structural change, involving a forward curvature of the upper part of the scapula, a shortening of the coraco-acromial ligament, or, according to Fitz, a tightness of the serratus magnus muscles, associated with weakness of the rhomboids and trapezius.

Fig. 38. — Anteroposterior tracings of the spine: *a*, Correct posture; *b*, first type of round back; *c*, extreme resistant round back in a young girl.

It is frequently discovered in girls about the age of puberty, when especial attention is apt to be paid to their figure and carriage.

Round shoulders are not likely to be outgrown, and patients usually become permanently and structurally set in the faulty position, with flattened chest-walls and distorted figure.

By adequate treatment all cases are capable of improvement, and almost all, except the most resistant, are capable of complete cure. Before beginning treatment it is important to differentiate between the flexible and the resistant cases and between both and arthritis, where pain is usually a prominent symptom. An irritated spine must also be excluded, as well as the early stage of Pott's disease, so that any case of sore spine before being treated by exercise should undergo a rigid examination, and be kept for some time under careful observation.

Treatment.—Treatment may be divided into—(1) Hygienic; (2) exercise; (3) stretching.

(1) *Hygienic.*—The patient should have the best available surroundings as to light, air, and food, because, as a rule, they are underdeveloped muscularly and have not the constitutional resistance nor the will-power of the average child. The muscle fatigue that comes on from the strained, fixed positions among school-children must be avoided by every available means. School furniture should be adjusted to prevent undue flexion of the back and forward bending of the head during reading and writing. Errors of refraction should be corrected. The clothing should be examined, and when found to be supported from the tip of the shoulders, the garments should be altered to bring the pressure in toward the root of the neck, instead of out on the shoulders.

Fig. 39. — Showing a common underwaist with the straps bearing upon the outer part or movable part of the shoulders (Goldthwait).

(2) *Exercise.*—In the treatment by exercise, expansion of the lungs by deep breathing to round out the flattened chest should be emphasized. The correct standing position and carriage of the body should be continually and persistently insisted upon. This must not be done by contracting the retractors of the shoulders, but rather by bringing in the chin and forcing the thorax forward and upward (Fig. 41), as already described. The muscles of the upper back must be strengthened to carry out their function of support, and the abdominal muscles must be developed and trained to overcome the weak and relaxed carriage of the protuberant belly. The following exercises would constitute a daily prescription:

Exercise I.—Patient standing in his habitual faulty position (Fig. 43). Place the hand about one inch in front of the sternum, and tell him to raise the chest and shove it forward to touch the hand without swaying the body. In doing this at first he will try to draw the shoulders back, contracting the trapezius and rhomboids. This fault must be overcome at the very beginning, and the shoulder muscles must be kept relaxed. Gradually increase the distance to which he can bring the chest forward, repeating it again and again until he can take the position without difficulty and with-

out contracting the muscles of the back. While in this position make him breathe deeply five times and then relax. This should be done

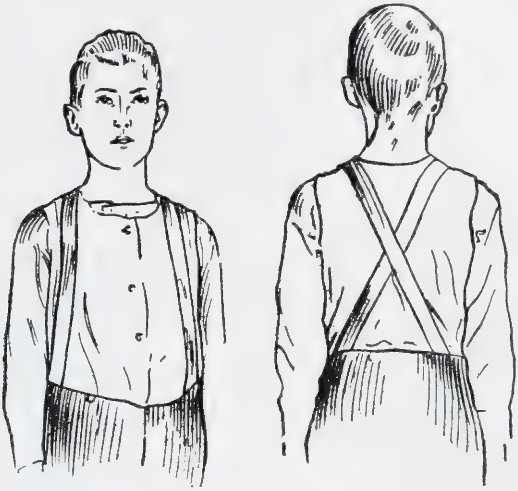


Fig. 40.—Correct support of clothing. The weight comes on the root of the neck instead of the shoulder-tips (Goldthwait).

Fig. 41.—Correct standing posture.

Fig. 42.—Incorrect standing posture.

before a mirror, so that he will recognize the feeling of the correct posture and associate it with the proper attitude, as seen in the glass. He should then try to take it without looking at the mirror. This

posture should be drilled into him until it becomes habitual, and until he can maintain it without discomfort.

R. J. Roberts, of Boston, is accustomed to tell his young men to press the back of their neck against their collar-button, considering this as the keynote of the position. In whatever way it is accomplished, the object is to get the proper relation between the thorax and the pelvis.

After repeating Exercise I twenty times take Exercise II.

Exercise II.—Arms forward raise, upward stretch, rise on tip-toe, inhale. Sideways lower, slowly press the arms back. Exhale (Figs. 102, 103, 106).

This exercise, when done correctly, expands the chest, bringing in all the extensors of the back and the levators of the shoulders.

Fig. 43.—Diagram showing the relation of the head, thorax, and pelvis in the incorrect standing position.

Fig. 44.—Diagram showing the relation of the head, thorax, and pelvis in the correct standing position.

Exercise III.—Patient standing, arms down and back, fingers interlocked and palms outward (Fig. 45). Extend the neck, roll the shoulders back and forearms into supination, the palms being first in, then down, and then out (Fig. 46). Reverse to starting position and relax.

This exercise is particularly valuable for projecting the chest forward, stretching the shortened ligaments, and drawing in the abdomen. Care should be taken to have the chin pressed backward when the arms are brought downward and turned outward. In resistant cases, where this exercise cannot be done with the fingers interlocked, a handkerchief tied in a loop may be substituted and held in the fingers. (See Fig. 88.)

Exercise IV.—Patient standing with the arms at the sides. Arms sideways, raise, upward stretch, inhale, forward bend, and rise. Arms sideways lower. Exhale. (See Figs. 107 and 108.)

In this exercise the lungs are filled when the chest is in the most favorable position for expansion. The breath is retained when the trunk is flexed, forcing the air into the cells of the lungs under pressure. The bending and rising bring into powerful action the extensors of the back and neck and the retractors of the shoulders.

Exercise V.—Patient lying prone upon a couch with the feet strapped or fixed by an assistant. Hands clasped behind the head. Raise the head and extend the spine, pressing the elbows backward (Fig. 47). Relax.

Fig. 45.

Fig. 46.

This exercise is a severe one on the extensors of the back and the retractors of the shoulders.

Exercise VI.—Patient lying in a prone position, arms at the sides. Raise the head (Fig. 49), bringing the arms forward (Fig. 50). Imitate the breast stroke in swimming (Fig. 51).

In this exercise the erector spinæ is kept in static contraction, while the retractors of the shoulder are alternately contracted and relaxed.

Stretching exercises that require the services of an assistant or a machine designed for the purpose should be associated with these voluntary movements. An adaptation of Sylvester's method of artificial respiration (Figs. 109 and 110) may be employed with good

effect, the upper dorsal region being supported by a hard pillow, the surgeon pulling at the end of the upper movement, stretching the thorax to its utmost. The intercostal machine is invaluable for securing the same kind of movement. Zander's machine, the

Fig. 47.—Raising the head and extending the spine, pressing elbows backward.

Fig. 48.—Deep breathing exercises introduced between two extension movements.

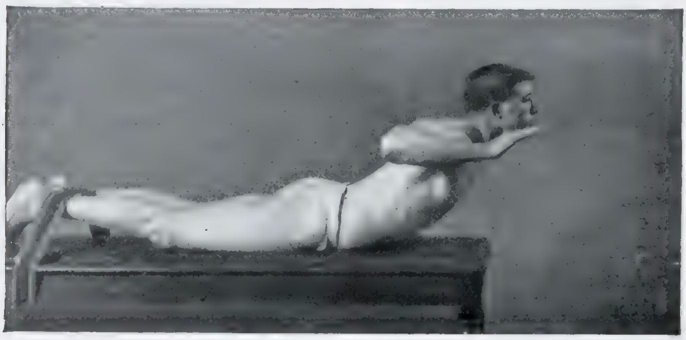


Fig. 49.—Raising the head.

"tower" (Fig. 7, p. 347), straps the shoulder backward and forces forward the rest of the body, imitating closely the movement and rhythm of ordinary respiration. The quarter-circle is another gymnastic machine designed to give breathing exercises, with the body held in an overcorrected position. Taylor's "spinal assistant"

(Fig. 52) produces the same effect by suspending the weight from the arms with accented pressure on the dorsal region, either from behind, forward, or laterally, as shown in the illustration. The main value of these stretching movements is on the ligaments, rather than on the muscles.

In slight cases of round shoulders the strapping described by

Fig. 50.—Bringing the arms forward.

Goldthwait, to draw the shoulders backward, is of real value. It is composed of firm webbing, one inch wide, carried as a loop around each shoulder, the hands crossing in the back and being attached to the belt of an ordinary stocking supporter. The attachment of the shoulder strap to the belt should be at the side, directly over the stocking straps, and the belt should be worn about the hips and not

Fig. 51.—Imitating the breast stroke of swimming.

about the waist, as is usual. The straps should be sewed where they cross at the back, over the angles of the scapulæ, but should not be sewed where they cross in the mid-line. This allows body movements, both to the side and forward, without straining upon the straps or changing the position of the belt level.

For more resistant cases, where very active stretching is necessary, Lovett's apparatus is the best. It consists of an oblong gas-pipe

frame. Hinged to this, near the middle, is another section of gas-pipe of the same shape and size as the upper half of the frame. To this movable section is fastened at right angles a gas-pipe bridge rising about eighteen inches above it and movable on it (Fig. 53). When prepared for use, two strips of webbing lying one over the other run from each of the two buckles at the bottom end of the frame. The lower pair are tightly drawn and run through buckles at the upper end of the movable section. The upper two are loosely fastened to the bridge. The patient is laid face downward on the webbing strips, protected by a piece of sheet-wadding if uncomfortable. The thighs are flexed and the feet rest on the floor, so that the lumbar spine is flattened. Two pieces of webbing are placed over the middorsal region from side to side, tied to the lower non-movable frame on each side, thus furnishing the resistance for the straightening of the spine when the upper end of the movable frame is raised, carrying with it the head and upper chest. After the patient is in place, the upper part of the frame is lifted, the amount of force permissible being not beyond the point of mild discomfort. Several stretchings are made of a few seconds each, the movable part of the frame being let down to rest the patient.

Fig. 52.—Taylor's spinal assistant for suspension and lateral pressure.

Flexible round shoulders in most cases yield to exercise alone, extending over a period of three to six months of daily treatment, but it may be advisable to maintain the improvement for a time by means of some such simple brace as the one described by Goldthwait, although fixation without exercise is irrational and leaves the condition worse than it found it. Some resistant cases will require stretching by the Lovett apparatus and fixation in the corrected position, combined with vigorous development of the muscles of the back and prolonged training in the corrected standing position.

Occasional cases in which there is structural deformity have been treated by cutting the coraco-acromial ligament, or an operation on the deformed scapulæ, as described by Goldthwait, but such cases are the exception and need not enter into the discussion.

After active treatment has ceased, the patient should be kept under supervision, reporting progress at least once a month for two years.

Uneven Shoulders.—It is the rule, rather than the exception, to find associated with round shoulders some inequality in their height. In 1000 consecutive examinations of supposedly normal young men the right shoulder was low in 140 cases and the left low in 20 cases, and tailors tell me that it is almost the rule to put extra padding in the right shoulder of coats for the sake of appearance.

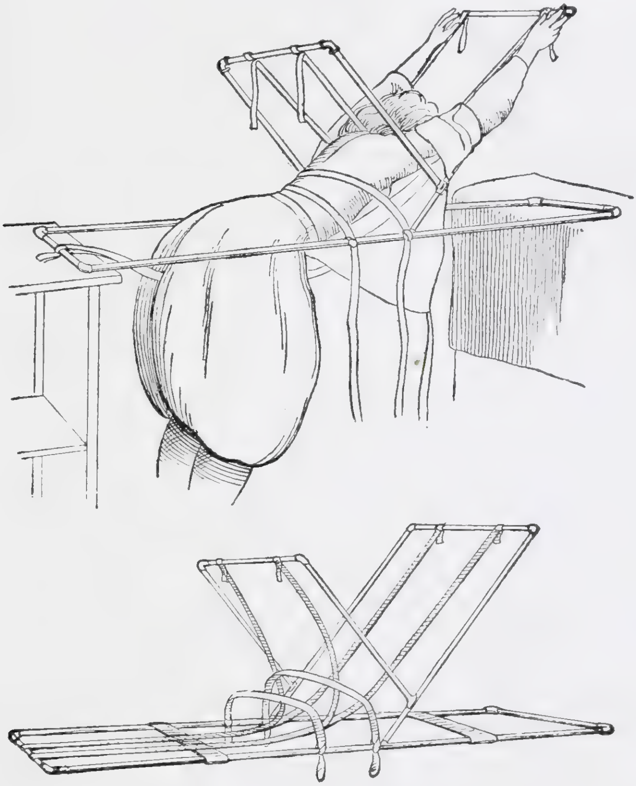


Fig. 53.—Apparatus for stretching round shoulders (modified from Lovett).

The causes of an irregularity varying from three-fourths to two inches are sometimes difficult to disentangle, but the carrying of weights, like school-books, and bad habits in sitting and standing, are among the most potent. The position of the child sitting at the school desk during writing favors it, since the left arm and shoulder are supported and the right lowered. Habitual standing with the weight on the right leg contributes to a good many cases, as will be seen in the description of scoliosis, but weights carried in the hand or

pressure on the right shoulder are the most direct, and it is a common thing to see this deformity in soldiers after carrying the rifle and bandolier during long marches. Fig. 54 shows a man, otherwise powerful, symmetric, and well developed, who acquired it in two years' active military service in South Africa, during which he had to make long marches with his rifle and cartridge belt pressing down on the right shoulder.

The great specialization of some games in which the right arm is almost exclusively used is blamed for many cases. Fencing, baseball pitching, and putting the shot are ready examples.

Fig. 54.—Lowering of the right shoulder from carrying a rifle and pressure of a bandolier for two years.

In response to an inquiry sent to 21 men who had the left lowered only, 3 acknowledged to left-handedness.

The patient placed before a mirror can almost always assume the correct standing posture by voluntary muscular effort, but to him it does not feel normal or natural, and he quickly relapses if left to himself.

Treatment.—In all straight and symmetric exercises the weaker side will get more work than the stronger, so that movements described for flat chest and round shoulders, all of which bring in equally the muscles of both sides, would be of some value in these cases. It is necessary, in addition to this, to develop the upper part of the trapezius, the rhomboids, and the deltoid of the lowered side, and the latissimus dorsi and inferior part of the pectorals on the opposite side, and for this purpose the following exercises should be given for a lowered right shoulder:

Exercise I.—Position, standing, arms down at the side. Right arm forward raise; inhale (Fig. 55); rise on the tip-toes; stretch; sideways lower; exhale. The left arm should be shoved downward while the right arm is raised.

This exercise brings into action the upper part of the trapezius, deltoid, rhomboids, and serratus magnus of the right side, and the latissimus dorsi and lower part of the pectoralis major on the left.

Exercise II.—Position, standing, arms down. Right arm sideways raise; inhale; forward bend (Fig. 56); upward stretch; arm sideways lower; exhale.

This exercise has the same effect as the first, with the additional advantage of stretching the right side of the trunk more than the left, as the body is bent forward.

Exercise III.—Position, prone, lying on plinth, right arm elevated, left arm forced downward. Extend the neck and back; relax (Fig. 58).

Exercise IV.—Position, back to the chest weight, floor attachment; raise and lower the right arm (Fig. 57). This brings into action the right deltoid, the upper part of the trapezius, the rhomboids, and the serratus magnus of the right side.

Exercise V.—Shrugging the right shoulder while holding a dumb-bell of 40 or 50 pounds (Figs. 59 and 60) has the contrary effect from continually holding the weight and keeping the muscles in tension. The intermittent contraction and relaxation of the muscles tend to strengthen and develop them, and so make them shorter when at rest, while continuous tension rapidly stretches them and destroys their tonicity.

Fig. 55.—Right arm forward raise.

The putting up of a light dumb-bell, five or ten pounds, from the floor to arms' length above the head, is another valuable exercise (Fig. 61).

The nautical wheel turned counter-clockwise also will help to raise a lowered right shoulder.

Hanging exercises, in which the weight is borne by the right arm with counter-pressure on the left side, are of slight assistance in stretching the latissimus dorsi on the right side, but do not affect the upper part of the trapezius or the serratus magnus, both of which are relaxed in this position.

The prognosis is good in all cases if these exercises be followed persistently and faithfully in the form of a daily prescription for three to six months. Most of the failures are caused by the carelessness of the surgeon or the laziness of the patient and by the readiness of the tailor to act as his accomplice.

Scoliosis.—During growth lateral deviations may also occur to overstretch the supporting muscles and ligaments, and even to distort the vertebræ themselves while in their plastic state.

The integrity of the spine is protected against the onset of deformity by three lines of defense of increasing strength: (1) The muscles forming an advanced mobile series of outposts brought into service, in relays, powerfully but intermittently; (2) the ligaments more resistant, but less mobile, requiring long-continued and persistent attacks to overcome their normal protective action; (3) the bones, which may be compared to the citadel, yielding to the influence of deformity only after the other two lines of defense have long since been carried. When they have adapted themselves to the deformity and have become set in their distortion, treatment can hope to be, at best, only

cosmetic in character, to conceal the deformity rather than to correct it.

Movements of the spine are flexion, extension, side bending, and torsion.

Fig. 56.—Forward bending.

Flexion takes place mostly in the lumbar and cervical regions, the dorsal backward convex curve being accentuated but slightly.

Extension is almost entirely in the lumbar and cervical regions, even in backward contortionists, who can place the head on the hips, the dorsal region remaining comparatively fixed. In side bending from the flexed position of the spine the lumbar region is locked, and the movement is in the dorsal region more than lower down. It is accompanied by rotation of the bodies of the dorsal vertebræ to the convex side of the lateral curve. Side bending from the position of extreme extension takes place in the lumbar region almost entirely, the dorsal vertebræ being locked. Rotation of the bodies of the lumbar vertebræ is to the concave side of the lateral curve.

Fig. 57.

Torsion in the erect position is greatest in the cervical region, gradually disappearing through the dorsal. In the lumbar region it is diminished by flexion or extension and is slight, even in the erect position.

The most freely movable regions are most abundantly provided with muscles, and it is to the analysis and application of their action that treatment of deviations by exercise must be directed.

The causes of scoliosis are both congenital and acquired. Among them may be mentioned wry-neck, defective hearing and vision, asymmetry (Figs. 62 and 63) or faulty development of the bones, like rickets, dislocation of the hip, arthritis, and uneven development of the lower extremities from joint disease or other causes. Astigmatism has been given a large place in the

causation of scoliosis by Gould, who has well described the tilting of the head in such cases, particularly when reading or writing.

It is to bad posture, however long continued, in standing, sitting,

Fig. 58.—Patient prone, extending neck and back.

and, lying joined with the carrying of weights in the hands or suspended from the shoulder, that we must look for the origin of the vast majority

Fig. 59.

Fig. 60.

Fig. 61.

of cases, which may be classed under the general heading of the *scoliosis of fatigue.*

A frequent fault in the standing posture is the habitual employment of one leg, usually the right one, as a base, the other foot being used as a prop (Fig. 64). This produces a C-shaped curve with marked lowering of the right shoulder and prominence of the right hip. Many children assume this position, in which the strain is borne by the ligaments of the hip and spine for long periods, and feel uncomfortable when the weight is transferred to the other foot. Such cases are nearly always accompanied by rounding of the shoulders, flattening of the chest, protrusion of the abdomen, and rotation of the vertebræ, all signs of muscular fatigue and ligamentous strain.

The sitting posture is beset with possibilities for deformity. The common habit of sitting with one foot tucked up on the seat is responsible for some cases, but, above all, the compulsory holding of any fixed position for long periods of time. We know that if we hold the arm out at right angles the pain and fatigue soon become intolerable, and few can stand the strain so long as five minutes. The greatest strain falls upon the deltoid, which has no relief from continuous action. The

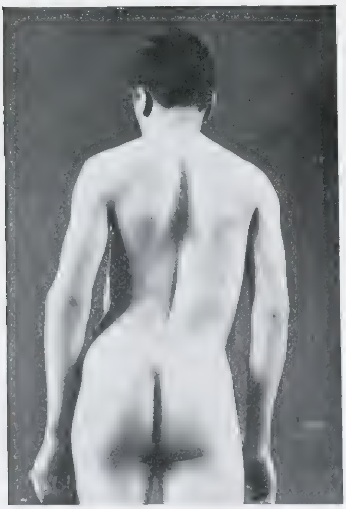


Fig. 62. Lateral curvature from uneven extremities and deformed pelvis. The black spots mark the posterior superior spine of the ilium.

Fig. 63. –The result of raising the foot three inches to bring the spines of the ilium to the same level.

same condition occurs in the back and shoulders of the school-child forced to remain sitting for any unusual length of time.

The complicated system of spinal muscles, by working in relays, postpones fatigue very considerably, the slightest change of movement bringing into action a new set and relieving the tired ones, and this constant desire for rest by movement is the most striking quality of all young animal life.

With the beginning of school-life the child is made to sit from three to six hours with but momentary rests at long intervals, and the resultant restlessness must be suppressed by the teacher for the sake of discipline. The rapid fatigue of the undeveloped muscles and the irregular compression of the

Fig. 64.—Lowering of the right shoulder from resting the weight on the right leg. One way in which a C-curve begins.

Fig. 65.—Pose from an antique statue of a boy, illustrating the attitude of rest with the weight on the right foot, the right hip projected, and the right shoulder lowered, forming a C-curve.

growing bones go far to fix the faulty posture, especially in those who are weak and delicate.

The influence of a bad sleeping posture in the causation of curvature has been well pointed out by G. W. Fitz, Boston (Fig. 66). The hips and shoulders, being the broadest part of the trunk, serve as points of support, and leave the middle portion of the body suspended between them, and as the period of sleep occupies one-half

to one-third of the child's growing time, this influence is of importance.

As will be seen by the illustration a patient with left convex curve in the lower dorsal region should not lie habitually upon the left side.

Curvature may begin at either end of the spinal column, the most flexible parts being in the lumbar and cervical regions. If it begins in the cervical region, from torticollis or from eye defects, as pointed out by Gould, other curves will be secondary, while if the curvature begins in the lumbar region, from unequal support of the pelvis, either in sitting or standing, the dorsal curvature will again be secondary. An S-shaped curve can be produced experimentally by raising the left side of the seat to tilt the pelvis, making a lumbar curve with the convexity to the right, and a compensating curve in the opposite direction (Figs. 67, 68).

Fig. 66.—A double curvature encouraged by bed posture, as seen in the upper picture, and corrected by turning over on the other side (Fitz).

Before beginning a course of treatment the extent of the curvature should be recorded if we are to follow the effects of treatment. This record must show the difference in the height of the acromia and inferior angles of the scapulæ, the deviation of the spinous processes from the straight line, the difference in outline and level of the hips and iliac crests, and, again, the picture will not be complete unless rotation of the vertebræ is shown in both the dorsal and lumbar regions, and, if necessary, the condition of the anterior and posterior curves.

An attempt has been made to fulfil these conditions in an instrument which I have employed for some years. It consists of a horizontal iron stand into which a rigid upright rod is firmly screwed. To this rod two jointed arms are attached by movable collars clamped by thumb-screws. The lower arm passes behind the patient and fixes

the hips by means of clamps, preventing any sideways movement. The upper arm passes in front of the patient and fixes the shoulders. To the collar of the upper arm a plate is hinged for the attachment of the pantograph, set to make the tracing in the proportion of 1 to 4. Ruled paper is stretched over the plate and held by clips behind. The pointer should be adjustable in length, short for the tracing of the spine and scapulæ, and capable of being lengthened for tracing the outline of the shoulders and hips.

To take a tracing the spinous processes are first marked with a flesh-pencil. The patient is placed on the stand with the heels together, the hips are clamped at the level at the trochanters, and the shoulder arm adjusted and clamped after the patient has settled into the habitual position. The line of the spine is followed by the short pointer (Fig. 69), the gluteal cleft and the points of the scapulæ

Fig. 67.—Straight spine with even support of the pelvis.

Fig. 68.—S-curve caused by uneven support of the pelvis in a normal individual.

marked; then an outline of the shoulders and hips is rapidly traced by lengthening the pointer to touch the most prominent parts. Cross-sections may be taken to show rotation by passing the end of the pantograph across the back, at the desired level, the patient bending forward (Fig. 70). A tracing of this kind gives an accurate map of the back, showing the difference in levels, deviation, and rotation, their extent being to scale, and estimated by counting the squares on the ruled paper.

These tracings should be repeated from month to month throughout a course of treatment.

The most frequent form of scoliosis is the total C-shaped curve involving the entire back (Fig. 72).

Among 571 school-children with lateral curvature out of 2134 children examined, 60.3 per cent. showed curves convex to the left,

21.1 per cent. showed a right convex curvature, and 8.5 per cent. showed compound convex curves.

The total curve is most commonly found in school-children, and is followed by the right dorsal and left lumbar. Transitional cases are nearly always preceded or accompanied by round shoulders, flat chest, and protruding abdomen, and by general carelessness in carrying the body weight when standing at rest, as in Fig. 64. This alone would tend to produce a well-marked total curve with

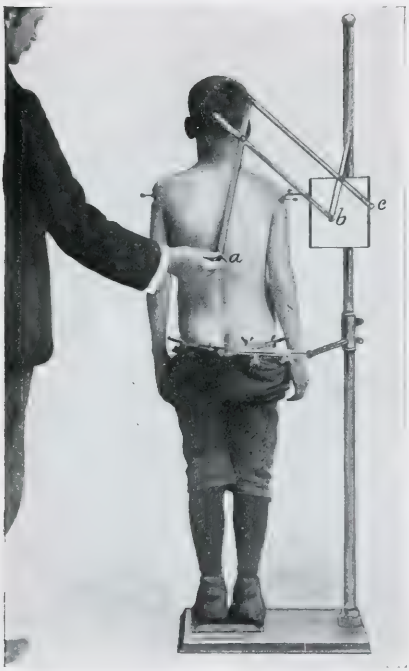


Fig. 69.—Making a tracing of the lateral deviation by the author's scoliosiometer: *a*, Pointer which follows the line of the spinous processes and tips of the scapulæ; *b*, pencil recording the tracing on paper to the scale of 1 to 4; *c*, fixed point of the pantograph.

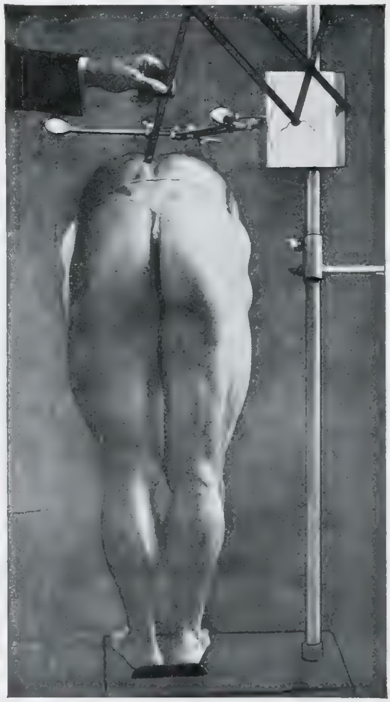


Fig. 70.—Making a tracing of the rotation at the lumbar region.

the convexity to the left. As this posture becomes fixed the bodies of the lumbar vertebræ rotate to the left, and this part of the curve tends to become more pronounced and localized, a compensating curve developing in the opposite direction in the dorsal region. This process, happily, may be arrested at any stage of its course.

Curvatures beginning at the upper end of the spinal column are usually caused in school-children by uncorrected astigmatism and by faulty positions in sitting and in writing, where the head is tilted

to the left and twisted to the right, as in facing a strong wind. This causes a rotation of the bodies of the cervical vertebræ to the right, carrying with it the bodies of the dorsal vertebræ, producing the characteristic right dorsal curvature, with rotation to the right, and followed by a left convex lumbar, the level of the greatest deviation in these cases being usually from the sixth to the eighth dorsal.

In total curvatures the deviation is greatest lower down—about the ninth or tenth dorsal, or even at the twelfth. In curvatures beginning from some distortion of the pelvis or irregularity in its support, the curvature is usually situated low down in the lumbar region (Fig. 74).

Symptoms.—The symptoms, apart from the deformity, may not be very prominent in slight cases. The dressmaker conspires to conceal it by making one side of the skirt longer or by changing on one side the distance of the arm-hole to the waist-band, but patients usually have a feeling of one-sidedness. They are often observed

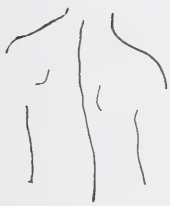


Fig. 71.—Tracing of scoliosis due to collapse of right side after empyema and resection of ribs.

Fig. 72.—C-curve in a young woman.

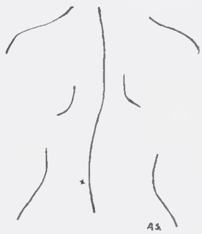


Fig. 73.—Tracing of typical S-shaped curve.

to have a distinct limp, and a very considerable number, especially young women, complain of backache, more or less severe, sometimes bilateral, and sometimes on one side only, usually situated in either the lumbar region or about the point of the scapulæ. In severe cases there may be pressure upon the nerve-roots, causing pain. The early onset of fatigue, with shortness of breath, is common on account of the diminished capacity of the lungs and interference with the heart action, but these symptoms are peculiar to the more aggravated cases. As the deformity tends to increase during the growing period, these symptoms may not become insistent until the approach to adult life, when the patient is prone to develop phthisis or to have disturbance of the digestion, impairment of the general vigor, and slow increase of asymmetry, with increasing pain in the back, as senile atrophy of the intervertebral discs progresses.

Prognosis.—Total functional curves may continue as such throughout life, increasing slightly, although, as a rule, they change to structural curves and become compound in form as they progress. Some

permanent deformity is certain in all cases where the vertebræ have become distorted and a functional curve has become structural.

Treatment.—By treatment all but structural cases should be capable of permanent cure, and even they should be in every case greatly improved, the deformity masked, and the general health and efficiency retained. This applies more especially to children who have not yet acquired their full growth. When full growth has been attained, before the case comes under observation, complete cure is not to be hoped for, and the only thing to be expected is some improvement in the general condition and a variable diminution of the deformity. Cases due to infantile paralysis or to the collapse of one side of the chest, from empyema, are peculiarly resistant, and must be treated with great caution. Cases due to rickets are also resistant, although most of them are capable of considerable improvement.

Fig. 74.—Tracing illustrating a **C**-curve as a result of uneven extremities.

The *treatment* of scoliosis falls naturally into two divisions: (1) The reformation of the physical habits and improvement of the general condition; (2) the correction of the deformity by exercise, stretching, and support.

Correct standing posture must be taught by the aid of a mirror, as described in the chapter on Round Shoulders. This must be insisted upon in season and out of season until it can be maintained without fatigue.

Astigmatism should be at once corrected where it is the cause of

Fig. 75.—Course of the **S**-curve under treatment.

tilting of the head, and the habits of school life should be carefully regulated.

The rule for the construction of a well-fitting desk is so simple that there seems no excuse for neglecting it.

The height of the seat from the floor should be such that in sitting the feet rest easily on the floor or on a foot-rest. The slope of the seat should be backward and downward, in the proportion of one in

twelve, the depth being about two-thirds the length of the thighs and the width that of the buttocks. Making it concave adds to the comfort. The back of the seat should have a slope backward of about one in twelve from a vertical line, and the back support should come to the middle of the shoulders and touch the small of the back. The height of the desk should be such that the back edge allows fair room to rest the forearm naturally with the elbow at the side, and the slope should be about one to six forward and upward, the edge overlapping the front edge of the seat by about one inch. The desk may well be made adjustable for distance (Fig. 76, *a–b*), so as to allow freedom in getting in and out, by pushing the desk-lid forward. These points are covered in the Garber adjustable desk, but no matter how well fitting the school furniture may be, unless there is constant change allowed, scoliosis is sure to develop in some growing children.

The raising of one side of the seat will reverse a beginning curvature (Figs. 67 and 68), and this may be used as an auxiliary means of treatment by placing the patient upon such a seat from a half to one hour daily. Where one leg is short, the foot should be raised by wearing an insole of cork in the boot; and a child who habitually rests with the weight on the right leg, as in Fig. 64, should be trained to reverse the resting posture by using his left leg as the habitual base of support.

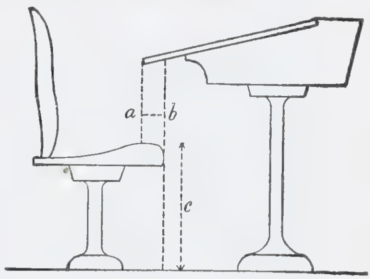


Fig. 76.—To show the measurements required in determining desk proportions; *a–b* is the distance which is here minus, because the edge of the desk overlaps the front of the seat.

The main corrective treatment of scoliosis must, however, be by active exercise and stretching, and the muscles must be developed and trained to maintain the correct posture with ease. Treatment must be thorough and regular, extending from half to one hour daily for six months at least; and even after an apparent cure has been obtained, the patient should be kept under close observation for at least two years, to check the first signs of relapse.

As most children suffering from scoliosis are below the normal in strength and resistance, it is essential that exercise should not be pushed beyond the point of general fatigue, and the greatest care should be taken to limit the number of muscle groups exercised to those more directly affected, so that the resulting fatigue may be localized to them and not spread over the whole muscular system, for most of the discredit under which the exercise treatment of scoliosis has labored has been due to the inaccuracy of the exercises.

Every course should begin with what is known as "straight work," such as is described for round shoulders, in which the muscles on both sides are equally employed, with special emphasis laid upon chest development, but in a few weeks one-sided movements should be

introduced in appropriate cases, such as are described for the raising of the right shoulder, and, gradually, stretching movements should be taught, like those pictured in Figs. 82 and 110 (pp. 393 and 405), the right or left foot only being used, and the surgeon grasping the left or right hand, and so producing a diagonal tension on the spine. All free movements should be done in the keynote position, which is found experimentally by holding the arms so as to give the greatest correction of the curvature. This may be with the right arm up and the left arm out, or with the right arm up and the left arm down, or with both arms above the head, or the right arm extended and the left down. It must be found after repeated trials for each individual case.

In applying asymmetric exercises it is to be remembered that the most freely movable regions of the spine are the most abundantly provided with muscles, and a muscle can be developed only by active contraction and relaxation. Continuous tension quickly tires and lowers its tone, as has been already stated, so that in prescribing exercise it is necessary to distinguish between those given for the purpose of increasing muscular tissue and power, which should be comparatively quick and frequently repeated, and those which aim at the stretching of muscles and ligaments, which should be slow and long maintained.

Fig. 77.—A girl aged seven years with severe osseous lateral curvature of the spine, in the "habitual" posture (Bernard Roth).

Fig. 78.—Girl aged seven years, with severe osseous lateral curvature of the spine, when placed in the "keynote" posture (Bernard Roth).

In describing the gymnastic treatment of scoliosis the curves will be considered in the order of their frequency, and without attempt-

ing to give an exhaustive list of all possible exercises, those that are described will be arranged in the form of prescriptions for typical cases and illustrated by case reports.

All exercises and stretching movements should be given daily, with a period of rest after three or four movements; they should be so alternated and combined that no two employing the same muscles in the same way should follow one another and so cause excessive fatigue.

The most frequent deformity is a total left scoliosis or C-shaped curve, and the following prescription of exercise would be indicated:

Exercise I.—Patient standing in the correct position, hands at the side.

Raise the right arm forward and upward; inhale; upward stretch; rise on tip-toes and raise the left foot sideways; upward stretch; lower the arm and foot to the standing position.

This movement will develop the upper part of the trapezius, rhomboids, and deltoid of the right side, raising the shoulder and

Fig. 79.—Raising right foot with weight attached.

stretching the thorax. At the same time the uneven support brings into strong action the lower part of the left erector spinæ.

Exercise II.—Position standing, fingers interlocked behind the back.

Movement: Roll the shoulders backward, supinating the arms (Figs. 45 and 46), and then bend the body to the left.

This exercise stretches all the anterior muscles and ligaments of the shoulder-girdle, improves its flexibility, and reverses the curve.

Exercise III.—Position standing, left foot forward in lunging position, hands on hips.

Movements: Raise the right arm sideways; inhale; upward stretch; forward bend until the right hand touches the floor in front of the left foot; upward stretch; exhale. This may be varied by bending from the standing position and raising the left arm (Fig. 81).

This movement, besides developing the upper right shoulder muscles, improves the lung power by filling the lungs in their most favorable position and compressing the air in the downward bending

movement. The right side of the thorax is stretched during the forward bending movement, and the left latissimus dorsi is contracted by pressing downward on the left hip with the left hand.

Exercise IV.—Patient supine on the plinth, with the right knee over the end, the left arm behind the back, and the right hand grasped by the surgeon.

Movement: Starting with the elbow at the side, the surgeon pulls the arm up slowly sideways, the patient resisting. When fully extended above the head, the surgeon exerts as much tension as possible, counting five. The patient then draws the arm down to the starting position, the surgeon resisting.

In this stretching movement the two points at which the stretching power is applied are the right hip and the right shoulder, so that this tension will reverse the curve and stretch the right side of the trunk.

Fig. 80.

Fig. 81.

Each of these exercises should be repeated at least twenty times, and should be followed by a short rest, after which the following should be given:

Exercise V.—Patient lying on the right side with the legs strapped to the plinth, the right hand supporting the head and the left hand on the hip.

Movement: Side flexion of the trunk (Fig. 83).

In this exercise it will be necessary for the surgeon to assist most patients at first and to urge them to bring the body as high as possible. The entire erector spinæ mass on the left side is powerfully employed,

and the effect may be still further increased by placing both hands behind the head.

Exercise VI.—Patient lying prone with both feet strapped to the plinth, right arm extended upward.

Movement: Trunk extension, forcing the right arm forward and the left arm backward (Fig. 84).

Fig. 82.—Stretching of right side.

Exercise VII.—Patient lying supine.

Movement: Raise the right arm forward, upward stretch, inhaling slowly; lower to the side, exhaling.

This should be repeated at the rate of twelve to the minute, and the maximum amount of chest expansion secured at each repetition.

Fig. 83.

Exercise VIII.—Patient lying prone, the left foot only fastened.

Movement: Trunk extension with the movement of swimming, as in Figs. 49–51. This should begin by repeating the swimming movement five times, followed by a rest. Gradually patients will be able to go up to twenty or thirty times without resting.

These exercises should be followed by a rest.

Exercise IX.—Suspension, with lateral traction. The patient puts the head in a Sayre sling and grasps the cord preparatory to self-suspension. A band of webbing is placed about the point of the greatest deviation on the left side, usually about the tenth dorsal (Fig. 85).

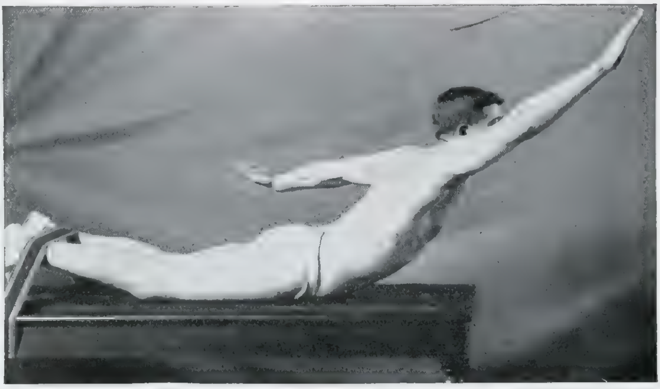


Fig. 84.

Fig. 85.—Self-suspension with pressure on the left side to correct rotation.

Movement: The patient, pulling on the cord, raises herself from the ground, while the surgeon, by means of a cord and pulley, draws her sideways, stretching the right side. Repeat ten times.

This should be followed by a rest.

Exercise X.—Right hand on the back of the head, left hand on the hip.

Movement: Side-bending to the left.

The treatment should end by deep, firm stroking of the back from above downward, about ten or twelve times on each side, using one hand to press upon the other.

In a right dorsal and left lumbar curvature (Fig. 73) the following prescription would be applicable:

Exercise I.—Position standing, hands on the hips.

Movement: Raise the left arm and left leg sideways; inhale and upward stretch; sideways; lower; exhale (Fig. 87).

In this the left side of the thorax, which is contracted by the rotation of the ribs on the right, will be stretched, and the left lumbar curve will be reversed by the tilting of the pelvis and the contraction of the left erector spinæ mass in the lumbar region.

Fig. 86.

Exercise II.—Patient standing, with the fingers interlocked. Rolling of the shoulders into supination, with forward bending and twisting to the right (Fig. 88).

In the flexed position of the spine side-bending is accompanied by rotation, chiefly in the cervical and upper dorsal spine, so that this exercise will have little effect on the lumbar curve, the lumbar vertebræ being locked during flexion of the spine.

Exercise III.—Patient standing, hands at the sides.

Movement: Forward lunge with the left foot, the right hand on the hip. Raise the left arm sideways; inhale; forward bend, touching the floor; rise; exhale; come back to the standing position (Fig. 89).

Exercise IV.—Patient lying supine on the plinth. Raise the right foot twelve inches from the plinth, pressing back with the left heel; hands on the hips.

The tension on the right foot should be increased by placing shot-bags across the ankle, starting with a weight of five pounds, and increasing it to ten or fifteen as the strength allows (Fig. 79, p. 391). The patient should be carefully instructed to relax the abdominal muscles so that the strain may fall upon the right psoas, which will pull the bodies of the lumbar vertebræ over to the right and so unwind a lumbar rotation to the left.

Exercise V.—Patient prone, the right foot fixed, the left arm up, and the right arm down.

Movement: Trunk extension, with the stretching of the right arm backward and the left arm forward (Fig. 90).

Exercise VI.—Patient supine, right knee over the end, as in Fig. 82, but right arm behind the back, left arm grasped by the surgeon.

Movement: The left arm is pulled upward and strong tension is put upon it by the surgeon. The patient then pulls the arm forward and downward, the surgeon resisting. In this way the rotation is unwound by the diagonal tension running from the right hip to the left shoulder, reversing the curves.

Exercise VII.—Patient lying on the right side, as in Fig. 83, but the right hand on the hip, the left hand behind the head.

Movement: Side flexion to the left.

This exercise is aimed at the lumbar curve, which will be reversed

Fig. 87.

Fig. 88.

by the side-bending to the left in the extended position of the spine, essentially a motion of the lumbar region, the bodies of the vertebræ turning toward the concavity of the curve.

Exercise VIII.—Patient recumbent, supine.

Raise the left arm and the right leg; inhale; lower, slowly exhale. This should be followed by a short rest.

Exercise IX.—Suspension by the Sayre sling.

Movement: Side traction, pressure being placed on the left lumbar region. Repeat from ten to twenty times.

Exercise X.—Arms behind the head; side flexion to the right (Fig. 150).

This should be followed by kneading and stroking, as previously described.

In a left dorsal and right lumbar curve (Fig. 93) practically

Fig. 89.

the same exercises may be used, except that in every case the opposite leg and arm are employed.

Curves due to infantile paralysis will require long-continued treatment, especially where they are severe and structural, localized

Fig. 90.

and fixed. In some of these cases the best that can be hoped for from gymnastics is to develop the general muscular system and to form compensating curves above and below the primary curve, thus giving a general appearance of symmetry to the outline of the back.

Where the curvature is due to inequality of the extremities, as

in the tracing, this must be corrected by raising the heel of the shortened side, which is sometimes all that is necessary (Figs. 62 and 63, p. 382, and Fig. 74, p. 388).

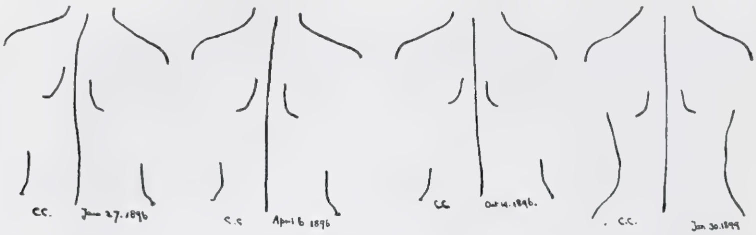


Fig. 91.—Four tracings illustrating the progress of an S-curve under treatment for three years.

Fig. 92.—Movement for left dorsal and right lumbar curve.

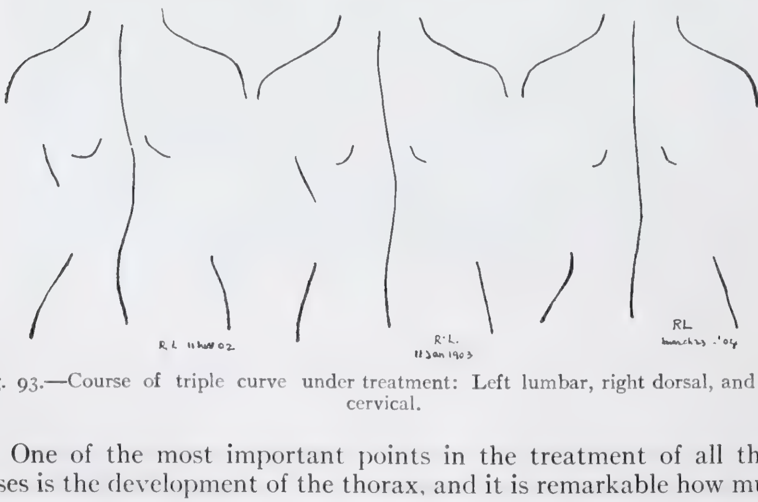


Fig. 93.—Course of triple curve under treatment: Left lumbar, right dorsal, and left cervical.

One of the most important points in the treatment of all these cases is the development of the thorax, and it is remarkable how much

improvement can be obtained in this direction by respiratory and stretching exercises.

I have seen an increase in lung capacity of 45 cubic inches in three months, while in thirty consecutive cases I find an average gain of 21 cubic inches.

Fig. 94.

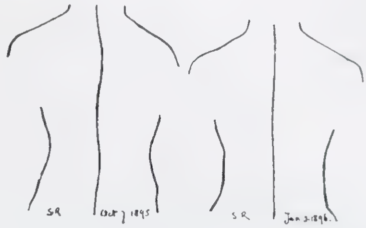


Fig. 95.—Tracings at the beginning and after three months of daily treatment for chest expansion and curvature.

In structural cases, where the treatment by gymnastics and posture is insufficient, stretching and retaining apparatus are necessary.

Among the simplest is the device (Figs. 96 and 97) designed by Robert Lovett.

The efficiency of this apparatus is greater than the same movement done during suspension, because stretching is done more easily when the spinal muscles are relaxed. Patients should be stretched up to

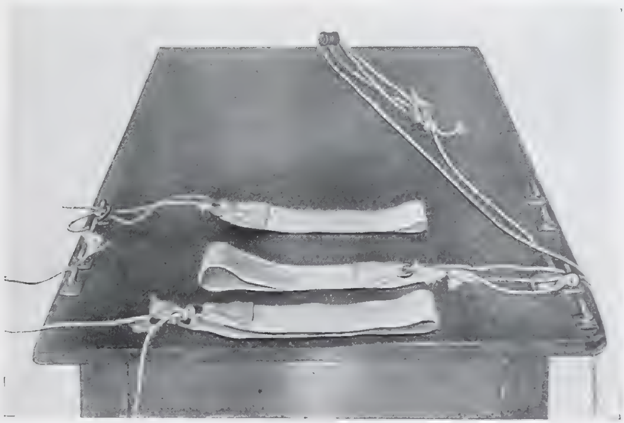


Fig. 96.—Stretching board with loops, ready for application to a *left* dorsal curve (Lovett).

the point of mild discomfort daily, and kept in the corrected position for fifteen or twenty minutes.

The application of apparatus in severe cases for retaining the improvement obtained by gymnastics and stretching need not be taken up here in detail. The steel brace and the plaster jacket

both have their advocates, but they should be applied only to retain the child in the best possible position during the growing period, and all apparatus should be easily removable, so as to permit of daily exercises, which should be persisted in for months or even years if one is to expect a permanent result.

Improvement or cure should not be considered permanent until

Fig. 97.—Stretching board with loops, applied to a patient with *right* dorsal curve (Lovett).

the correct position is maintained without apparatus from month to month, as shown by repeated records.

Pulmonary Tuberculosis.—In the treatment of pulmonary tuberculosis the place of exercise has been well defined by Kinghorn,* who, after speaking of the open-air treatment and the treatment by rest,

Fig. 98.—Course of triple curve under treatment by exercise and stretching only.

advises the patient to begin with walking, at first on level ground, for ten or fifteen minutes, every second day for several weeks, then every day for several weeks, and at last twice a day. He quotes the rule of Brehmer: "The healthy man sits down because he is tired; the con-

* Montreal Med. Jour.

sumptive should sit down so as not to become tired." Patients should be told that all overexertion is poison, and that their feelings should be their guides at all times. The acceleration of the pulse, perspiration, palpitation, rise of temperature, feelings of weakness, discomfort, and headache, are all signs that he has overstepped his limit.

When the patient stands these little walks without harm; when the weight increases or holds its own, the exercise may be extended under careful supervision, but mountain-climbing should never be permitted.

In cases where no lesion can be found, but where the tendency is shown by the history of exposure to infection, by family history, or by the formation of the chest, much good may be expected from open-air exercise, accompanied by training of the respiratory powers. Deep breathing is a muscular act capable of education, and the capacity of the lungs or mobility of the thoracic walls can be increased, as well as the strength of any other part of the muscular system, while the general circulation, the skin, the appetite, and the digestion all share in the heightened activity, and healthful sleep is insured by the resultant moderate fatigue.

Fig. 99.

Exercise for this purpose should be general and special. Singing and elocution lessons are valuable, and the practice on a wind instrument has been recommended. Running and climbing are of the greatest value for increasing the breathing capacity if kept within the limits of fatigue. All exercises should be prescribed in writing, with the most minute directions, as to time frequency and severity, and a record of the patient's weight should be kept, and frequent examinations made to determine his progress, a loss of weight being followed by a reduction of exercise.

Daily supervised exercises are necessary to increase rapidly the power of chest expansion and vital capacity. They should be directed to a training in the best methods of breathing, to the stretching and developing of the chest and abdominal walls, and should be preceded and followed by accurate measurements and spirometer records. They should include both active, duplicate, and passive movements, but it must be remembered that, however deep the respiratory movement may be, the amount of oxygen absorbed is only in proportion to the need of the body. The oxygen in the blood remains measurably constant, and the only way to increase its absorption by the tissues is to do work that causes the breaking down of oxygen compounds. Deep breathing would result naturally from more demand, but it would not create this demand. Its rôle will

be to strengthen the intrinsic and accessory muscles of respiration; to teach the coördination necessary for deep breathing, and to massage the abdominal contents by wider excursions of the diaphragm.

Fig. 100. — Inhalation — abdominal. The abdomen is protruded without expanding the thorax.

Fig. 101. — Exhalation — abdominal. The abdomen is indrawn and the breath expelled without contracting the chest.

Fig. 102.

Fig. 103.

Deep breathing alone repeated a number of times during the day is useful, and its practice should be made part of every day's régime.

The normal respiratory act is a composite of two distinct types

of breathing—thoracic and abdominal. The thoracic type predominates almost to the suppression of the other among all, irrespective of sex, who wear constricting clothing about the waist-line, and the

Fig. 104.—Thoracic breathing—inhalation.

Fig. 105.—Thoracic breathing—exhalation. The girth of the abdomen remains unchanged.

first care must be to reëstablish control of the diaphragm and abdominal walls. The following exercises should be practised before a mirror:

Exercise I.—Patient standing. Place the hands across the ab-

Fig. 106.

Fig. 107.

domen. Inhale deeply. Exhale by pressing on the abdominal wall, keeping the thorax fixed in the position of inspiration (Fig. 99). Repeat this movement five times slowly with the thoracic wall

fixed, using the movement of the abdominal walls only. Rest. After a little practice this movement should be done with the hands at the sides.

Exercise II.—Patient standing. Place the hands across the abdomen. Inhale forcibly by pushing out the abdominal walls, keeping the thoracic wall fixed as in expiration. Exhale by drawing in the abdomen.

Repeat five times slowly. Rest. As soon as control has been obtained, practise this exercise with the hands placed behind the back (Figs. 101 and 102).

Exercise III.—Patient standing with the hands across the abdomen. Inhale forcibly, using the thorax only, without movement of the abdominal wall. Repeat five times slowly and rest.

As soon as control of the abdominal walls has been obtained, do this exercise with the hands behind the back (Figs. 104 and 105).

Thoracic breathing can be forced still further, and the walls of the chest stretched by using the arms in the following exercise:

Fig. 108.

Exercise IV.—Patient standing with the arms at the sides. Raise both arms forward (Fig. 102) until they are above the head. Inhale. Hold the breath and stretch upward. Rise on tip-toes (Fig. 103). Lower the arms sideways, pressing backward and exhaling (Fig. 106). Repeat twenty times at the rate of about five to the minute.

Patients will sometimes have a feeling of dizziness and may even stagger and fall at the sudden change of the blood-pressure in the head, but this need cause no alarm.

Exercise V.—Patient standing with the arms at the sides. Raise both arms sideways, pressing back and inhaling (Fig. 107) until they are above the head. Hold the breath and bend forward, keeping the knees straight until the hands touch the floor (Fig. 108). Rise, keeping the arms above the head. Lower the arms sideways, pressing backward and exhaling.

Repeat twenty times at the rate of five to the minute.

This exercise compresses the air in the lungs and forces it into the cells that are little used in ordinary breathing.

The following duplicate and passive movements may be employed for increasing the chest mobility and improving the respiration.

Exercise VI.—The patient lying supine on a plinth, with the feet fixed, the arms bent, and the palms up. The surgeon grasps the hand, palm to palm (Fig. 109), and pulls upward, to full extension of the arms, the patient resisting (Fig. 110). The patient then pulls downward and forward to the first position, the surgeon resisting.

Inhale as the arms go up and exhale as they come down.

Exercise VII.—The patient lying supine on a plinth, the lower

Fig. 109.—Artificial respiration. Surgeon pulling up and patient resisting.

part of the thorax supported by a roller four inches high, the arms behind the head, and the chest expanded in inhalation. The surgeon

Fig. 110.—Stretching of the thorax by traction on the arms in the movement of artificial respiration.

presses on both sides of the lower thorax, directing the patient to exhale (Fig. 111).

Repeat twenty times at the rate of about ten to the minute.

A valuable exercise is that given by Zander's machine, known as the "tower," in which pressure is placed on the back by a cushioned pad and the shoulders are drawn upward and backward rhythmically with the respiration. (See Fig. 7, p. 347.)

If the tubercular process is active in the lung, deep breathing will only irritate and aggravate what nature attempts to splint by limiting the movement over the affected area, and in some cases a hemorrhage may be brought on.

In the application of exercise every attendant condition should be made as favorable as possible at all times, to get the best therapeutic results. Fresh air should be supplied in abundance, and treatment should be given in the open air or a well-ventilated room. Many of the disorders of the respiratory tract are due to the impurity, rather than to the temperature, of the air breathed. Regularity and persistence on the part of the patient are absolutely necessary,

Fig. 111.

and the benefit from half an hour's exercise repeated daily is incomparably greater and surer than an equivalent amount taken at long, irregular intervals.

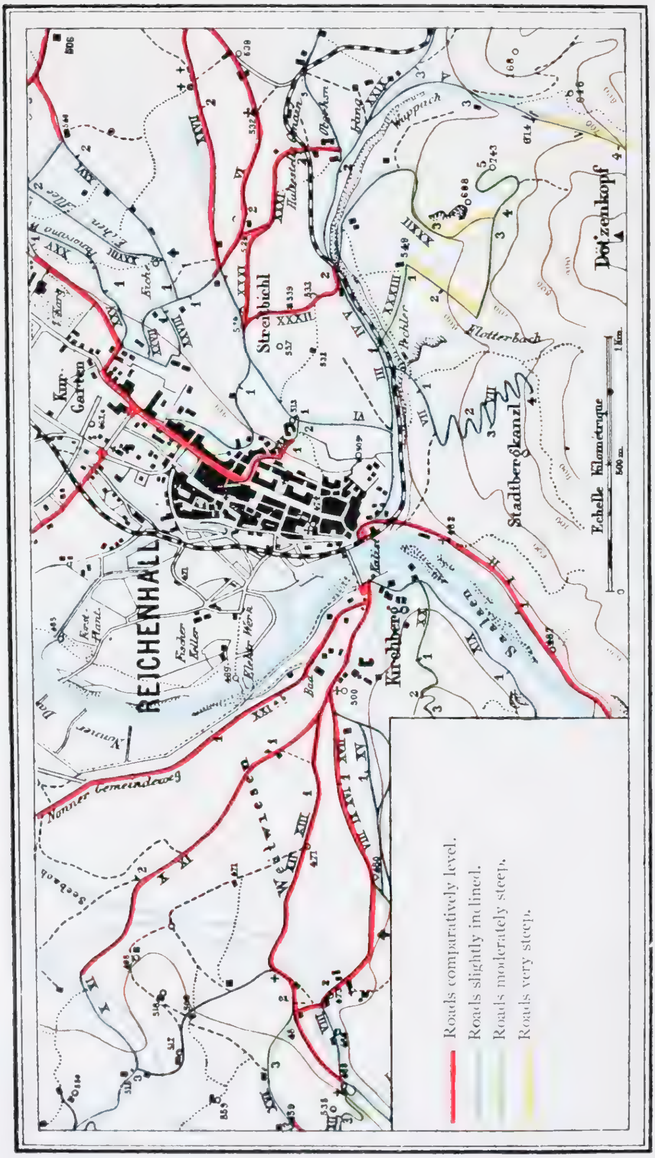
Disorders of the Circulation

The aim of exercise in the treatment of disorders of the circulation is to reduce a high pulse-rate by flushing the peripheral vessels; to postpone the onset of breathlessness by deepening the respiration and improving the muscular tone of the heart; to remove the incumbering fat which muffles its movements; and to prevent palpitation by acting both directly and indirectly on the cardiac nerves.

For this purpose exercises of effort and of endurance each have had their advocates.

Exercises of endurance, like walking and hill climbing, have had

PLATE I.



Red, roads comparatively level; purple, roads slightly inclined; green, roads moderately steep; yellow, roads very steep (Lagrange).

their chief supporters in the persons of Stokes, of Dublin, and Oertel, of Munich.

Exercises of effort have been employed with the greatest success by Heineman and the brothers Schott, at Bad Nauheim. They have always been confined to single efforts of the most simple kind, with rests between them, accompanied by massage and combined with regulation of diet and the administration of simple or carbonated brine baths.

All movements of the extremities, especially the legs, draw the blood out from the heart and abdomen and act as depletive influences. The back trembling given by Zander's machine (Fig. 40) has a powerful influence in reducing a rapid pulse, as have vibrations given along the back, from the first to the fourth dorsal. These procedures have the added advantages of being applicable to a patient who is bed-ridden, and to whom movements of the arms and legs must be given with the greatest caution. In slighter cases, particularly those in which the heart's action is impeded by deposits of fat, the endurance required for Oertel's Terrain Cure may be called upon.

While the Swedes and the brothers Schott have the gymnastic side of this treatment, the "pedestrian exercise" has been developed by Oertel into a system in which he combined walking and hill-climbing with restriction of fluids. To the treatment by exercise he thus adds the drying out of the tissues. He made his patients walk on mountainous roads of different steepness for a period strictly regulated, gradually increasing the time and steepness of the road. It is a form of athletic training beginning very cautiously, and based on the principle that function makes structure, although in these pathologic conditions it must be kept strictly within the limits of resistance by the watchfulness of a physician. His system was founded on the result of treatment in his own case.

Of the cures he established, the one at Reichenhall is typical, and a map shows the details (Plate 1). The course was regulated with care and minuteness. The paths were marked with stations, benches were placed for resting, and the trees beside the road had bands or flags of red, purple, green, or yellow, the colors representing the degree of its slant. The exercise was thus prescribed in degrees of increasing distance and steepness.

The range of the Oertel cure is strictly limited. It is, first of all, a preventive measure, and can be employed with advantage to improve the general nutrition and to prevent fatty infiltration from becoming localized in the heart. Even in cases where this has already occurred, it is still of great value, as it also is where the compensation has been already established by milder means.

Where compensation is broken down, and where the patient is compelled to remain in bed, massage and the milder treatment by gymnastics, which are under more accurate control, have better results. They act more directly upon the peripheral circulation by unloading the engorged veins without unduly overworking the heart

itself, and such a course may serve as a good preparation for the Oertel treatment, where it would have been dangerous to begin with it.

The application of massage and gymnastics has been most carefully studied and perfected by Auguste and Theodor Schott at Bad Nauheim. The treatment consists of regulated movements of the body, beginning at the extremities and employing the large muscle masses, combined with massage and the systematic use of carbonated brine baths, such as are found at the Nauheim springs. The effect of the baths is to stimulate and flush the skin, and so reduce the frequency of the pulse and increase its force. They can be prepared artificially.

The exercises are all duplicate movements, and each one must be slowly and evenly made, with a definite, firm effort on the part of the patient. A short interval should be left between them to enjoin slow and regular breathing and to prevent the possibility of heart-strain. The patient should be constantly warned of the danger of holding his breath during the effort, for by this act an undue and unnecessary strain is put on the heart-walls already impaired by disease. The exercises should stop short of perspiration and palpitation, and the operator should be on the lookout for dilatation of the nostrils, drawing down the corners of the mouth, duskiness or pallor of the cheeks and lips, yawning, sweating, or palpitation.

The pulse should be frequently examined during treatment, and examination before and after treatment should show a constant reduction in the dulness over both the heart and the liver, accompanied by a sense of general relief and freedom lasting several hours. The pulse is increased in volume as its rate is reduced, and the breathing is made slower and deeper. The color of the lips and face is improved, and the size of the liver, when congested, is notably diminished. Marked diuresis usually follows after a few days' exercise.

The movements cover in regular order, first, the muscles of the arms and forearms; then those of the trunk, thighs, and legs, exercising mildly every important group in the body by single contractions.

The following is the order of the exercises given by Bezly Thorne, in his book on the "Schott Methods of Treatment." For further instruction in the position of the operator's hands and other particulars the reader is referred to the illustrations. All the movements are done with resistance from the patient. This resistance must be made very mild at the beginning of the treatment, the tendency being to employ too much force. As the patient shows capacity for enduring the fatigue the amount of resistance may be gradually increased, but treatment should, if anything, err on the side of safety, especially if any signs of distress are noticed.

Fig. 112.

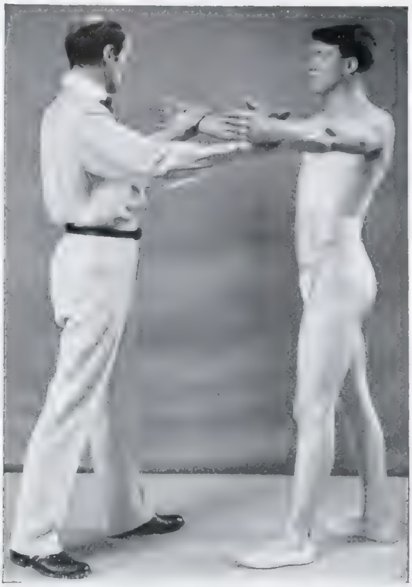


Fig. 113.

Figs. 112, 113.—*Exercise I.* Spread the arms (Fig. 112) until they are in line at the level of the shoulders. Bring them together (Fig. 113).

Fig. 114.

Fig. 115.

Figs. 114, 115.—*Exercise II.* Flex the forearm (Fig. 114). Extend the forearm (Fig. 115).

Fig. 116.

Fig. 117.

Figs. 116, 117.—*Exercise III.* Raise the arm sideways, palms upward (Fig. 116) until the thumbs touch above the head. Sideways lower (Fig. 117).

Fig. 118.

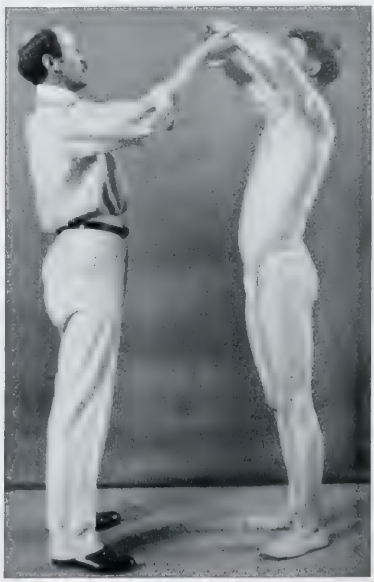


Fig. 119.

Figs. 118, 119.—*Exercise IV.* Press together the knuckles of both hands with the fingers flexed at the second joint. Raise the arms (Fig. 118) above the head. Lower the arms (Fig. 119) to the starting-point, in front of the abdomen.

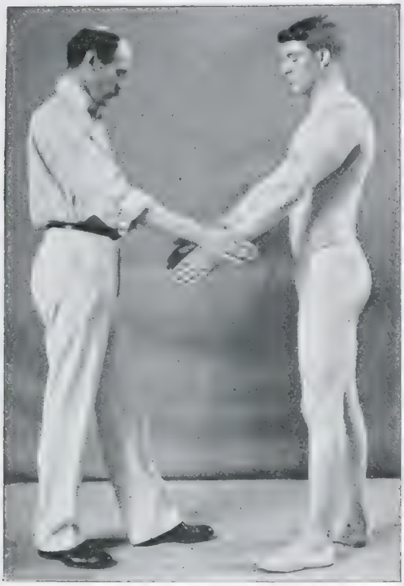


Fig. 120.

Fig. 121.

Figs. 120, 121.—*Exercise V.* Arms forward raise (Fig. 120) until vertically above the head. Forward lower (Fig. 121).

Fig. 122.

Fig. 123.

Figs. 122, 123.—*Exercise VI.* Forward flexion of the trunk (Fig. 122). Extension (Fig. 123).

Fig. 124. Fig. 125.

Figs. 124, 125.—*Exercise VII.* Trunk rotation. The operator must change his position from Fig. 124 to Fig. 125, as the patient turns, keeping up even resistance throughout the entire movement, and passing partially around him.

Fig. 126.—*Exercise VIII.* Flex the trunk to the right and to the left alternately. Straighten.

Exercise IX.—This movement is identical with Exercise II (Figs. 114, 115), except that the fists are clenched.

Exercise X.—This movement is the same as Exercise IX, except that the arm is at the side.

Fig. 127.—*Exercise XI.* Rotate the arm forward, upward, backward, and downward.

Fig. 128.—*Exercise XII.* Push both arms backward; draw them forward.

Fig. 129.

Fig. 130.

Figs. 129, 130.—*Exercise XIII.* Flex the thigh, with knee bent (Fig. 129). Relax. Extend the thigh (Fig. 130).

Fig. 131.

Fig. 132.

Figs. 131, 132.—*Exercise XIV.* Extend the leg and bring the straight leg forward (Fig. 131). Draw the leg backward (Fig. 132).

Fig. 133.

Fig. 134.

Figs. 133, 134.—*Exercise XV.* Flex the leg and thigh (Fig. 133). Extend the leg (Fig. 134).

Fig. 135.—*Exercise XVI.* Abduct the leg. Adduct the leg.

Exercise XVII.—Arms extended horizontally. Rotate forward and backward with resistance.

Fig. 136.—*Exercise XVIII.* Extend the hand. Flex the hand.

Fig. 137.—*Exercise XIX.* Flex the foot. Extend the foot.

This completes the full set of exercises, although many patients at first are unable to take the entire series. The resistance should not be very great in the beginning, and should be increased only as the patient shows the capacity to endure it. The rate should be slow and uniform, and abundant rest given between each exercise until the individual's powers and limitations have been gaged. Most of them may be done in bed if necessary.

Some form of artificial respiration may be profitably added to any treatment of these conditions, either in the forms already described or in the chest-raising or shoulder-raising (Fig. 138) described by Satterthwaite,* in which the patient inhales as the operator lifts, and exhales as the operator relaxes. This is repeated eight to sixteen times, with one or two natural respirations between each movement. Satterthwaite has further modified the technic of the Schott treatment by arranging the exercises in series of progressing difficulty, which he names Schemes I, II, and III, including massage of the thigh and back.

The following is a brief outline of the course of exercise carried on for the first two weeks:

* Intern. Clinics, vol. i, thirteenth series.

Fig. 138.

SCHEME No. I

1.	Chest lifting, lying or sitting	2 minutes.
	Intermission	1 minute.
2.	Foot and leg massage	2 minutes.
	Intermission	1 minute.
3.	Forearm flexion and extension	1 "
	Intermission	1 "
4.	Hand and forearm massage	2 minutes.
	Intermission	1 minute.
5.	Leg and thigh flexion and extension	2 minutes.
	Intermission	1 minute.
6.	Arm and shoulder massage	2 minutes.
	Intermission	1 minute.
7.	Thigh flexion and extension	2 minutes.
	Intermission	1 minute.
8.	Chest percussion	2 minutes.
	Intermission	1 minute.
9.	Trunk flexion and extension	2 minutes.
	Intermission	1 minute.
10.	Thigh and back massage	2 minutes.
	Total length of séance	28 minutes.

This is increased in severity and the order slightly changed in Scheme No. II, which is carried on for the third and fourth weeks:

SCHEME No. II

1.	Chest lifting, lying or sitting	2 minutes.
	Intermission	1 minute.
2.	Foot and leg massage	2 minutes.
	Intermsision	1 minute.

3.	Forearm flexion and extension	2 minutes.
	Intermission	1 minute.
4.	Hand and forearm massage	2 minutes.
	Intermission	1 minute.
5.	Leg abduction and adduction	3 minutes.
	Intermission	1 minute.
6.	Arm and shoulder massage	2 minutes.
	Intermission	1 minute.
7.	Trunk rotation	3 minutes.
	Intermission	1 minute.
8.	Chest percussion	2 minutes.
	Intermission	1 minute.
9.	Arm separation	3 minutes.
	Intermission	1 minute.
10.	Thigh and back massage	3 minutes.
	Total duration of séance	33 minutes.

Scheme No. III

1.	Chest lifting	2 minutes.
	Intermission	1 minute.
2.	Foot and leg massage	2 minutes.
	Intermission	1 minute.
3.	Quarter circling (forward and backward)	4 minutes.
	Intermission	1 minute.
4.	Hand and forearm massage	2 minutes.
	Intermission	1 minute.
5.	Head rotation or flexion	3 minutes.
	Intermission	1 minute.
6.	Arm and shoulder massage	2 minutes.
	Intermission	1 minute.
7.	Trunk twisting	4 minutes.
	Intermission	1 minute.
8.	Chest percussion	2 minutes.
	Intermission	1 minute.
9.	Trunk flexion (laterally)	4 minutes.
	Intermission	1 minute.
10.	Thigh and back massage	3 minutes.
	Total duration of séance	37 minutes.

For the fifth and sixth weeks a further change in the series is made, and some new exercises are introduced that might not be well borne at the beginning of the course, particularly quarter circling and head rotation.

It will be noticed that in this final series the exercises involve newer and larger groups of muscles, and that all the great muscles of the body have been exercised. The duration of the séance is also longer, and more force should be applied. The movements should be very slow, and the intermission should be carefully observed, the fault of the operator being usually in shortening the intermission, increasing the amount, and using undue force. The patient should also be urged to breathe freely and naturally, and the operator should be on the lookout for irregular breathing, pallor, blueness of the lips or face, or other sign of personal discomfort. Upon the appearance of any of these signs exercise must be suspended, since they indicate that there has been undue resistance or that the movement has been too rapid or the intervals of rest curtailed. Heineman, of Nauheim, was strongly of the opinion that no exercise should be used in which the hands are brought above the level of the shoulders, on account of

the increased work required of the heart in raising the column of blood to this unaccustomed height. With this opinion Satterthwaite agrees. Good results may be expected from exercise in almost all disorders of the circulatory system except arteriosclerosis.

The exercise treatment is unusually successful in conditions of heart weakness complicated by obesity, where improvement should be noted from the first. It is of undoubted value in most valvular disease, with signs of failing compensation, the dilatation of the peripheral vessels resulting from the exercises being followed by an improvement in the strength of the pulse and a lowering of the rate, an improvement that may be maintained for years. In most cases the patients may return to their ordinary occupations and duties, and if signs of relapse begin to appear, the taking of a course is sufficient to reëstablish the equilibrium until the heart shares in the inevitable degeneration of advanced old age.

Obesity

The excessive accumulation of fat must be considered as a symptom rather than as a disease. It is due to overnutrition, to underoxidation, or to a combination of both acting together.

When the allurements of the table are too great for the body's needs, the surplus is stored up as fat in the tissues least disturbed by muscular action, and local deposits are made in the region of the abdomen and hips or in a general layer throughout the subcutaneous tissue of the entire body.

Heredity has a marked influence in this fat-making tendency, about 60 per cent. of cases reported by Anders having this history, while its association with gout, that other disorder of overfeeding and underexercising, was found in 43 per cent. of his cases.*

The normal oxidation of the ingested food may be hindered by a sedentary life involving little tissue waste from muscular exercise, or by the mental and physical torpor and habitual inactivity of the too ardent pupils of Silenus, whose fat is also protected from combustion by the rapidly oxidizing alcohol, which retards all tissue waste, and so favors increase in bulk. It may also be hindered by lack of the proper functioning of the thyroid gland.

Fat is a cheaper form of tissue than muscle, requiring as it does a less abundant blood-supply, and its presence should be considered as an evidence of lowered nutrition.

As the amount of fat increases the desire for exercise diminishes, and the capacity for activity is lessened, because of the speedy exhaustion that follows any unusual muscular work.

Local obesity is frequently found about the waist-line, the deposits occurring in the abdominal walls and in the mesentery and omentum. This, when excessive, gives rise to a pronounced deformity, simulating tumors, pregnancy, or dropsy. In those who do a good deal of walking

* See "System of Medicine," Osler and McCrae, vol. i, 846.

the legs may remain comparatively normal in size, while the abdomen is pendulous.

Deposits of fat are common in the regions of the neck, giving rise to the double or triple chin, and in women, especially, it tends to accumulate about the hips and buttocks, the Hottentot Venus being distinguished by the size of her buttocks, due to the excessive accumulation of fat in that region.

The local deposit becomes more dangerous when it is in the pericardium and about the heart-wall, but this seldom occurs unassociated with general obesity.

When obesity is general in its distribution, it may be slight, moderate, or excessive.

While the first of these forms requires no definite treatment except the employment of every effort to prevent its further development, particularly if complications are present, the second or third form calls urgently for reduction by diet and exercise.

When obesity is moderate or extreme, the physician may be consulted from vanity, which may thus become one of the most powerful levers in his hands to insure the thorough and complete carrying out of the irksome rules that the patient must follow if the desired result is to be obtained. This seemingly trivial consideration is one on which the success of the treatment often hinges in the ease-loving, luxurious class from which so many of these patients come.

The prognosis in any particular case depends on the reaction of the circulation to exercise. If the onset of breathlessness, palpitation, irregularity, and thready pulse is rapid or extreme, the "outlook is gloomy" (Anders). If, on the other hand, the perspiration is profuse, the general condition and color remain good, and the pulse strong and regular after exertion, much may be expected from a reduction course.

Most of the causes of death in obese cases are due directly or indirectly to affections of the circulatory system, and its condition must be the keynote for treatment, as was recognized by Oertel in his "terrain cure," already described.

The fact that obesity is frequently but a symptom emphasizes the necessity for a preliminary examination to determine the presence of any of the many complications that are usually associated with it. In this examination habits of life, particularly with reference to diet and exercise, should be noted fully and accurately; the pulse should be examined carefully—lying down, standing, before and after light exercise, like forward bending, stationary running, or hopping; the blood-pressure should be estimated and a blood-count made to determine the presence of anemia. The lungs should also be examined for bronchitis, and a series of physical measurements taken, including the weight and girths.

In all diseases that impose increased work on the heart, like arteriosclerosis or emphysema, there is hypertrophy, with danger of dilatation and insufficiency, especially when the body is encum-

bered by excessive fat. The reduction of this fat constitutes one of the most valuable means in the treatment of most circulatory diseases, unless they are so far advanced as to render restoration of the heart to its functional activity impossible. Cases in which slight disorders of the circulatory apparatus are present give the most satisfactory results, while even in advanced cases improvement can be obtained by beginning gradually and watching the heart condition carefully. When complicated by diseases of the kidneys, like atrophic nephritis, obesity is a real menace, and the reduction is not contraindicated, but advised (von Noorden).

Chronic bronchitis is a frequent complication of obesity, and the removal of superfluous fat will enable the patient to breathe more deeply, encouraging a free circulation of blood through the lungs, so that such cases sometimes heal under this treatment alone.

Chronic articular rheumatism favors obesity by preventing the patient from moving freely, particularly if the regions of the legs or pelvis are affected. Anders found it in 35.5 per cent. of his cases. The same may be said of gout, the reduction treatment of which, through diet and exercise, is of the first importance. Most gouty middle-aged men present a history of violent indulgence in physical exercise during youth, followed by a luxurious and inactive later life, with overfeeding and excessive indulgence in alcoholic liquors.

In diabetes a reduction cure should never be undertaken, especially if the obesity be only slight or moderate, although in cases where it is excessive, accompanied by heart symptoms, the patient should, where possible, be relieved of any excessive fat. Only in this way can the heart be protected from excessive strain, but it should be used with the greatest caution.

In selecting cases for the reduction cure three considerations should be held in mind: first, the amount of inconvenience the obesity causes; second, the presence and extent of the complications referred to above; and third, the age and general nutrition of the patient.

In young and sound adults active courses of five weeks or more may be repeatedly undertaken with safety, allowing intervals during which the loss of weight is merely maintained. In those of advancing age, where the obesity is extreme and the vital energies are beginning to fail, a reduction cure would only accelerate decay and lead to rapid loss in strength and functional power, with the continual added risk of heart failure.

Reduction cures may be divided into three classes or degrees of rapidity:

1. The first degree, in which the loss is very slow, the patient losing two or three pounds a month. It applies to those with an enviable amount of fat which shows a tendency to increase. It does not require great sacrifice from the patient, who must alter her diet by the reduction of fat, starchy and sweet foods, restrict or abandon alcoholic beverages, take only foods of small caloric value, and engage in regular active physical exercise.

2. The second degree, in which loss should be from five to ten pounds a month, applies to strong, plethoric subjects, who can safely indulge in active exercise. The diet is more strict, and the exercises more varied. It is especially valuable for individuals in whom complicating disorders of the heart, arteries, bronchi, or digestive apparatus render it impossible to take from the start the more rapid or—

3. The third degree of the reduction cure, which should be carefully supervised and may be carried out at an institution with advantage. As much as thirty pounds a month can be lost with safety, but five or six weeks is the longest time during which it should be put in force. In most cases it will be necessary to carry it on for four to six weeks and then have a month or two of less strenuous exercise and regimen, repeating the course thus intermittently until the desired loss of flesh has been attained.

The reduction treatment falls under the three heads of diet, exercise, and drug therapy.

The patient's general mode of life must be regulated, always a

Fig. 139.

difficult feat to accomplish. Habits of ease and indolence should be replaced by greater general activity, and interest in outdoor games, like golf and walking excursions, should be created to impel her to take a large amount of general exercise.

When the accumulation of fat is unevenly distributed, a daily prescription of ten exercises should be given, to include the entire muscular system, but with emphasis on the regions where the deposit is thickest, for fat tends to accumulate in the subcutaneous tissue covering the groups that are dormant, like the abdominals or muscles of the neck. Such exercises have been shown in Figs. 99, 107, 108, 150, 151, and 152.

When the omentum, mesentery, and abdominal walls are excessively overburdened, the exercises shown in Figs. 150, 151, and 152 are of special value. To these may be added the three following, and selection made from them all to suit the special case:

Exercise I.—Patient lying supine, arms above the head, grasping a support. Raise both feet twelve inches without bending the knees. Alternately raise and lower the feet (Fig. 139) ten times without

touching the table. The extent of the raising and lowering should not be more than twelve inches.

This brings the abdominal muscles into action, and should be repeated with rests up to thirty times.

Exercise II.—Patient lying supine, hands on the hips. Raise the head and shoulders until the feet can be seen. Twist to the

Fig. 140.

right, to the left, and slowly return to the starting position (Fig. 149). This may be used as an introductory exercise to the next, in which the same muscles are employed with greater vigor.

Exercise III.—Patient lying supine with the feet fixed and hands clasped behind the head. Raise the body to the upright position, and slowly lower to the starting-point (Fig. 140). This may be accentuated by having the trunk overextended, as in Fig. 141, which

Fig. 141.

is a form of the same exercise which can be rendered still more difficult by having the arms behind the head, as shown in the position of Fig. 140.

A prescription should begin with the lightest exercise, and the dosage should be increased rapidly in length and severity according to the muscular strength and the condition of the pulse.

After each of the first two or three treatments massage is of distinct value in relieving the muscular soreness, but it seems to have no direct effect in reducing the weight.

Accompanying this gymnastic treatment, regulated walking, at first on level ground, and then up an increasingly steep incline, is of the utmost value, beginning with a climb sufficient to produce moderate breathlessness, and increasing the length and steepness as the patient's ability improves. This is the Oertel "terrain cure."

A daily treatment, such as outlined above, accompanied by proper regulation of the diet, and sometimes the exhibition of thyroid extract, should steadily and consistently bring down the weight in moderate and even extreme cases of obesity.

During a reduction cure the heart should be carefully examined from time to time, and the work decreased if signs of palpitation or edema of the extremities are found. Sometimes, when loss of weight is rapid and obtained by means of drugs and diet alone, without care to improve the muscle tone and so to support the viscera, certain complications arise (constipation, hernia, and gastroptosis), particularly in middle-aged and flabby women. Displacement of the kidneys and uterus may also be traced to the rapid absorption of the surrounding fat, and symptoms caused by such ptoses have in rare cases been found to be more troublesome than the obesity itself.

Other Disorders of Nutrition

Gout.—The rôle of exercise in the prevention and treatment of gout occupies an important place in every discussion of this disease.

Like obesity, with which it is so often associated, gout is usually a disease of overnutrition and underelimination, and the indications would be to decrease the intake and increase the excretion of waste by all the avenues.

The rules for diet are still the subject of dispute, but all writers agree that exercise is of great value in reducing the weight of the gouty patient when obese, and of increasing the activity of the skin and lungs.

The nature and dosage of the exercise must be regulated according to the condition of the patient. In young and vigorous subjects almost any of the active athletic sports appropriate to their age may be engaged in. (These are enumerated in the Table of Sports.)

The great majority of patients will require exercises of endurance, like walking, which should be regulated in distance and speed. Golf has a peculiar value, from the fascination it possesses for individuals of all ages, a point not to be lost sight of in the management of self-indulgent cases. Horseback-riding has the added advantage of vigorous massage, especially if the horse be trotted, and if the appetite resulting from the open-air exercise be kept within the limits of discretion.

For those who are unable to take more active exercise a course of gymnastics, including duplicate passive manipulation and general massage, is highly beneficial, increasing the elimination without undue fatigue.

It must not be forgotten that a debauch of exercise in a valetudinarian may precipitate an acute attack by throwing suddenly into the circulation an excess of fatigue products, so that great care should be observed to begin gradually and increase the amount as the system accommodates itself to the necessity for more active excretion.

Diabetes.—In the hygienic treatment of diabetes exercise has an important place, since muscular action favors the combustion of sugar, from whatever source it may be derived, and among diabetics the presence of constipation favors the onset of coma.

When present, constipation should be corrected by local and general massage daily, and by the simpler forms of free or duplicate movements.

When the patient is sufficiently strong, he should be made to live as much as possible out-of-doors in a dry, warm climate, and a daily task should be set for him. The exercise should be gentle in character and carried out systematically. Gardening and walking, golf, or tennis should be the forms selected, but the patient should be warned to stop within the limits of fatigue.

A course can be carried on to the best advantage in a sanatorium, where the conveniences for bathing and massage are found, and where the habits of life can be regulated with greater hope of success.

Rheumatism.—The manifestations of rheumatism, whether they appear in the muscles or in the joints, may often be treated by vibration and massage, with very considerable success.

In muscular rheumatism the sternomastoid, the erector spinæ muscles, and the lumbar fascia are favorite sites for the attack.

The pain of this condition is exceedingly acute, and requires rest and counterirritation.

Vibration may be applied to inhibit the pain, by using the ball attachment, a medium stroke, and deep pressure several times a day over the spinal centers governing these parts, and the soft brush and rapid stroke over the affected parts themselves several times a day if the pain is acute. Massage is also useful, after the acuteness has abated, in soothing the irritation by gentle stroking and friction, increasing in force with the improved toleration of the subject. The evils resulting from forced inaction in patients who are suffering from muscular rheumatism, either in the lumbar region or elsewhere, is counterbalanced better by general massage than in any other way. The movements used vary from gentle stroking to deep kneading of the muscle masses, with manipulation to extend the stiffened joints gradually, but without causing severe persistent pain.

Arthritis deformans is an incurable disease, but the inevitable progress of deformity can be held back and great comfort can be given to the patient by vibration, massage, and manipulation.

Ankylosis may be prevented by checking the formation of adhesions, and the stretching and breaking down of those already formed, while atrophy of the muscles, always a pronounced symptom, may be delayed.

Douglas Graham reports most encouraging results in a number of cases treated by himself, five out of six showing marked improvement. His mode of procedure was deep manipulation without friction, passive motion as far as the pain would allow, and sometimes farther, and resistive movements as soon as they could be done. He disregards pain if it rapidly disappears after the treatment; if it persists, treatment must be suspended.

He recommends kneading, with one hand, to break up indurations or disperse effusions, while the other pushes along the circulation in the veins and lymphatics above the joint.

Massage would not be used, of course, when the disease is very active.*

Gastritis.—Among the most amenable of the disturbances of nutrition to treatment by exercise are constipation and certain cases of chronic gastritis and diarrhea. Much attention has already been called to the inevitable disturbances of the digestive organs found in those leading a sedentary life, especially if they are gormandizers. But there is a class of cases in which the gastric disturbances are due to nervous causes much more than to indiscretion at the table. In advising massage or active movements for cases of chronic gastritis, great care should be taken, as in diabetes, to stop the exercise before reaching the point of exhaustion, and mild exercises of endurance, like walking, in addition to massage of the abdominal walls, should be the forms recommended.

In nervous dyspepsia, which is so frequently a symptom of neurasthenia or hysteria, the rest cure of Weir Mitchell, with careful regulation of the diet, massage, and light resistive exercises, leading on to more active movements, should be given. In all such cases of gastritis massage should be given about two hours after a meal and should include pressure and kneading of the hypochondriac and epigastric regions, from left to right and downward.

These movements give immediate relief in some cases. They force the stomach-contents into the duodenum, stimulate the action of the liver, and alternately compress and relax the gall-bladder. This should be followed by kneading along the course of the colon and vibratory massage over the spine, from the fourth to the tenth dorsal, whenever tender points can be made out. The relief from the feeling of oppression and the more distressing nervous symptoms so frequently present in these conditions is often rapid and complete.

Constipation.—Constipation may be due to constitutional peculiarities, to sedentary habits, to certain diseases, such as anemia or neurasthenia, chronic affections of the liver and stomach, or the abuse of purgatives. A general atony of the intestines accompanies weakness of the abdominal muscles in obesity and debility, and lassitude, headache, and mental depression are the most frequent symptoms which attend it; but persistent constipation may exist for weeks without other symptoms. Individuals differ greatly in this respect.

* Graham, "Massage," p. 410.

A careful inquiry into the probable causes should be made in all cases of constipation. Some change in diet or occupation may be responsible, as is so frequently found among college students after leaving home. About 12 per cent. of college students complain of constipation in their preliminary physical examination, and most satisfactory results have been obtained by having them follow a list of five simple exercises for the abdominal muscles, which are repeated daily twenty times each.

When the causes are complicated and the condition persistent, all the resources of exercise should be brought to bear on the case, as well as the regulation of the diet and the drinking freely of mineral waters or other light laxatives.

The application should be in the form of massage, vibration,

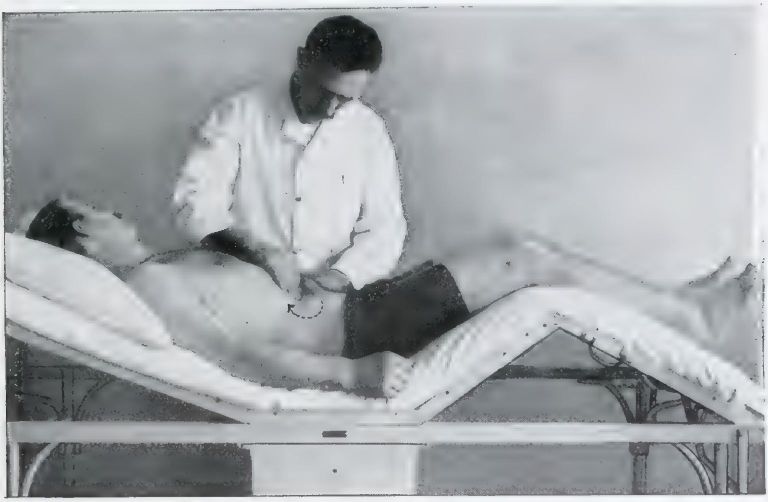


Fig. 142.—Deep rotating pressure massage (Gant).

duplicate and active movements, and the cultivation of regular and systematic habits. The massage should be very deep and slow, following the course of the colon, beginning in the right iliac region, passing upward to the ribs, across the abdomen, just above the umbilicus, and down the left side, terminating in deep, slow, circular movements in the left iliac region, over the sigmoid flexure and the rectum (Fig. 142). These kneading movements should be done very slowly, with firm, deep, and insistent pressure, the knees of the patient being drawn up and the abdominal walls relaxed. This part of the treatment should last at least ten minutes daily.

A cannon-ball covered with chamois leather has been used for the same purpose, and most sanatoriums have the Zander machine, on which the patient lies face downward, the abdomen resting on a loose leather diaphragm, beneath which a ball, set in motion by a

motor, follows the course of the colon, giving continuous upward pressure. These movements are not so effective, however, as the trained human hand. The administration of vibrations along both sides of the spine, from the first to the fourth lumbar, will alone give

Fig. 143.

immediate relief in some cases. Massage alone is scarcely ever sufficient in the treatment of constipation, and certain active movements are necessary to supplement the more passive forms.

Among the exercises that have proved of value may be cited the turning of the nautical wheel and the trunk rotation described in Exercises I and II for abdominal weakness (Figs. 149, 150, 151).

Fig. 144.

Two exercises may be described that act directly by pressure on the abdominal contents:

Exercise I.—Patient lying supine on a couch, arms at the sides. Raise the right leg with knee bent. Clasp the hands over it and press it in against the abdominal wall. Repeat with the left (Fig. 143). Repeat twenty times.

Exercise II.—Patient sitting astride a plinth, arms behind the back. Trunk circumduction bending well forward to the right, then forward and to the left (Fig. 144). Repeat twenty times.

Circumduction of the pelvis is given most effectively by Zander's "camel," the patient sitting on an eccentrically moving saddle, or on the "horse," which is a substitute in movement for the trot, and riding on horseback itself is to be strongly recommended when available.

The effects of treatment should be noticed from the first, and relief is usually immediate and made permanent by continuing the improved physical habits.

Hernia.—Weakness of the abdominal muscles and fascia is responsible not only for many of the more chronic affections of the gastro-intestinal tract, due to insufficient support or to lack of the normal massage which the diaphragm and the abdominal walls should give to them, but the relaxation of the openings through which the blood-vessels and other structures pass out of the cavity leads to actual hernia of the viscera.

When hernia takes place at the umbilicus, there is a stretching of the fibrous tissue alone. When it takes place at the femoral ring, it is merely a dilatation of the innermost compartment of the femoral sheath. Inguinal hernia, which is very much the most common form, is, however, in part due to a stretching and spreading apart of

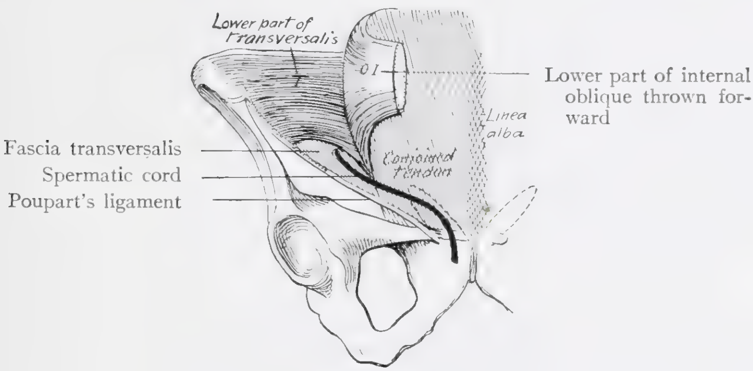


Fig. 145.—Deep layer, showing internal ring and transversalis muscle. The dotted line shows the attachment of internal oblique.

muscle and tendon, when not congenital, and exercise may be of marked assistance in strengthening and closing the internal and external abdominal rings, and so helping to guard against its advent or prevent its return.

The internal abdominal ring is found just beneath the crescentic arch of the inferior border of the transversalis muscle. It is at this point that the vas deferens in the male and the round ligament in the female enter the abdominal wall. The transversalis takes its origin from the outer third of Poupart's ligament. The internal oblique has its origin from the outer half, so that its lower fibers cover the internal abdominal ring as by a lid, and the development of this muscle has a distinct influence on the ring's integrity. The external abdominal ring is a slit between the tendinous pillars of the external oblique, and every contraction of this muscle pulls these pillars together, closing it. This action of the muscle serves as an automatic protector of the opening during active exercise.

The inguinal canal, which is normally collapsed, is bounded, then, superficially, from without inward, first, by the external and internal oblique; second, by the external oblique alone. Hernia may enter the canal at the internal ring, or break in through the fascia that guards its center or inner end, tearing ahead of it or pushing

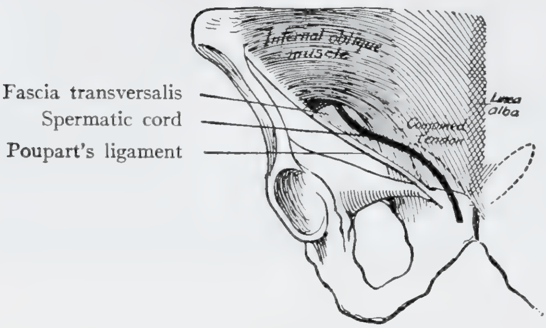


Fig. 146.—Attachment of internal oblique, showing the covering of the cord.

aside the weakened conjoined tendon of the transversalis and internal oblique; but in all cases it makes its exit by spreading apart the columns of the external abdominal ring.

In threatened or actual inguinal hernia much can be done by strengthening the external and internal oblique and the transversalis

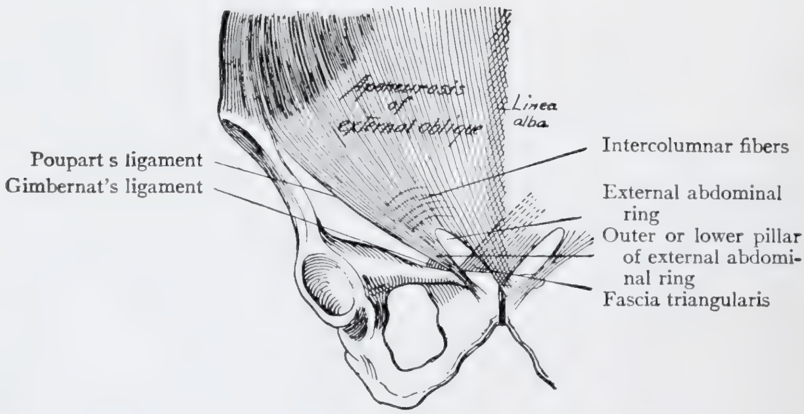


Fig. 147.—Superficial layer and external abdominal ring.

muscles by active movements. The most suitable cases for this treatment are in children and adolescents, where the condition is not congenital and where natural growth assists in the process of repair, although good results have been obtained up to fifty years of age, either where hernia is actually present or where there seem to be the

premonitory symptoms, such as a dull, aching pain in one or both inguinal regions, after some unusual muscular strain or fatigue, in patients having unusually dilated external rings. There is tenderness and a distinct impulse on coughing, but no actual hernia.

All hernias should, of course, be reduced and retained, preferably by a truss that does not present a convexity of surface great enough to enter and spread the abdominal ring.

In a recent hernia, where pain is present, the patient should remain quiet for a week or two, to get accustomed to the feel of the truss, and should then begin a course of light work for the abdominal muscles, as well as more general exercise for the whole muscular system. These exercises should be done daily and should be increased in number, complexity, and resistance.

Great stress should be laid on teaching control of the abdominal muscles by forced breathing and abdominal exercises. The extent to which specialization and rhythmic contraction of these muscles can be carried is shown in the movements of the Oriental *danse du ventre.* As the strength and control of the abdominal muscles increases, the work is intensified and extended. Seaver allows his patients the most trying gymnastic feats, such as the layout on the

Fig. 148.—Seaver's flat truss pad.

horizontal bar. The movements must be varied. Such a movement as lying on the back and raising both legs to a perpendicular position does not produce the desired result, as the strain falls chiefly on the rectus abdominis and psoas muscles.

The most effective movements are those in which flexion of the trunk is accompanied by side-twisting. Great stress should be laid on the deepening and raising of the chest, thus drawing up the abdominal contents, and reducing the downward thrust of the thorax and upper abdominal structures.

During exercise the abdominal rings should be protected by the truss or by the finger placed so as to keep up a continuous pressure.

A day's work should begin with Exercises Nos. I, II, and IV, recommended for the development of thoracic and abdominal breathing, and then the following movements should be introduced:

Exercise I.—Patient lying on the back, one hand behind the neck. The other placed so that the middle finger covers the inguinal canal and external ring (Fig. 149). Raise the head and shoulders, twisting to the right for a hernia of the left side. Repeat twenty times without holding the breath. In a double hernia both hands should cover the abdominal ring and the twisting should be to alternate sides.

Exercise II.—Patient standing, hands clasped behind the head.

Trunk circumduction to the right (Fig. 150), backward (Fig. 151), to the left and forward (Fig. 152). Repeat five times and reverse up to twenty times. The breath should not be held during this exercise and the hernia should be kept up by the truss.

Fig. 149.

This movement brings into action all the abdominal muscles, and keeps the chest in the best possible position.

Exercise III.—Patient seated, facing stall bars, feet fixed, hands

Fig. 150.

Fig. 151.

on the hips, with fingers over the ring. Backward bending and twisting to the right and to the left alternately, without holding the breath. Repeat twenty times.

This brings in all the abdominal muscles, the lateral twisting especially causing a powerful action of the obliques. It may be modified by placing the hands behind the head (Fig. 153) after the muscles have been developed enough to stand it, the truss being in place.

The nautical wheel is a valuable piece of apparatus in the treatment of this condition, as are all the lateral trunk movements of the Swedish gymnastics.

Massage with the finger-tips, consisting of kneading and pétrissage, should be used over the abdominal rings at the end of each treatment, to stimulate the local circulation and promote their contraction.

Under this developmental treatment Seaver reports that over 70 per cent. of his cases have been relieved of the necessity of wearing a truss of any kind, and my experience would confirm his observations.

Fig. 152.

I have also seen the greatest benefit resulting from it in men up to fifty years of age, the general improvement in tone of the abdominal muscles and relief from the constant pain and dragging sensation being complete, while the muscles acquire an alertness in contraction that prevents their being taken by surprise by an unexpected movement or strain.

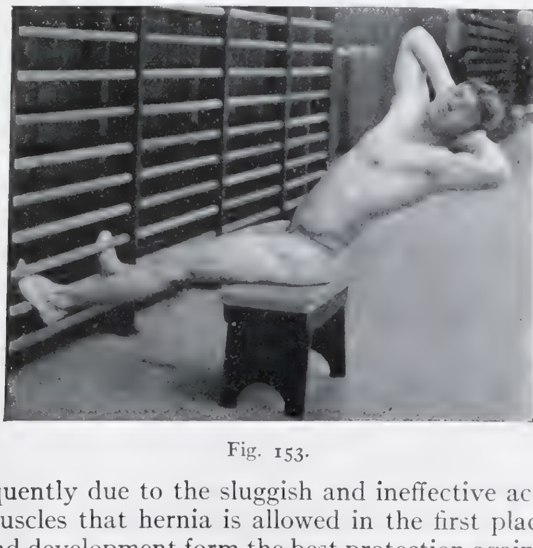


Fig. 153.

It is frequently due to the sluggish and ineffective action of these neglected muscles that hernia is allowed in the first place, and their education and development form the best protection against its return.

Nervous Diseases

Massage, mechanical vibration, and active exercise influence disorders of the nervous system through their power to control pain, to improve the nutrition of the affected region or the general health of the patient, and to reëducate disordered or impaired coördination.

Inflammatory Conditions of the Nerves.—In acute inflammation of

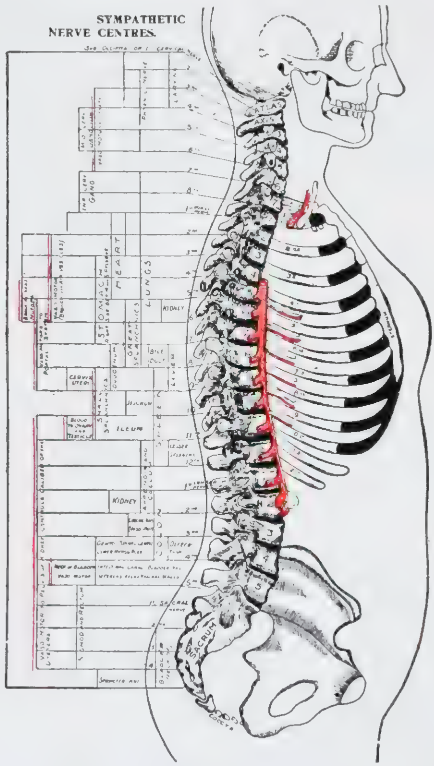


Fig. 154.—Diagram showing the areas in the spinal cord from which the nerves controlling the various organs and parts of the body are given off. The red lines in the table indicate vasomotor areas. Stimulation of the centers, indicated in the diagram, will affect the organs controlled by them; see the table at the left of the diagram (Pilgrim).

the mucous membranes of the throat and lungs or of the abdominal organs, points painful to pressure are found along the spine, at the level from which the sensory nerve supply of those areas or organs is derived.

The application of massage or vibration over these painful points, which mark the posterior primary divisions of the cervical or dorsal nerves, is generally followed by temporary relief of the symptoms. The points at which this stimulation should be applied are shown on

the accompanying diagram, and its amount and nature have already been described under the heading of Mechanical Massage.

Vibration over the lower lumbar and sacral regions for inflammation of the sciatic nerve is frequently followed by immediate relaxation of muscular spasm.

In sciatic neuritis this treatment has been used with great success, either in the form of vibrations, as described above, or after the method of A. Symonds Eccles, who starts with two daily treatments of five or ten minutes after the first few days of the disease, gradually increasing them to twenty minutes each. He uses friction and kneading directly along the course of the nerve and its branches, beginning at the heel and working upward.

In the later stages, when the pain is almost gone and stimulation well borne, hacking movements and deep vibration are added. Passive movements, in which the thigh is flexed, the knee-joint being kept in extension, stretch the nerve and frequently give relief; and, finally, toward the end of the treatment, active movements are of value in counteracting the atrophy that results from inaction and the disease itself.

Graham deprecates the use of massage over the sciatic nerve, and confines his manipulations to the muscle masses of the front and sides of the thigh, with gentle stroking only on the posterior aspect of the limb. Where hacking and percussion are used, the movements should be gentle, and any increase in the pain after massage should be a sign to desist.

Massage is not well borne in brachial neuritis, especially during the acuteness of the attack, and absolute rest is then essential. Only in the later stages may it be employed, and then with precautions to avoid a reawakening of the inflammatory process.

Neuralgia.—Of the many forms of neuralgia, the intercostal is the most amenable to treatment, and the trifacial the least affected by massage and vibration. In most cases the temperature of the painful area is lowered two or three degrees and the vessels are hard and cord-like.

DuBois Réymond, himself a martyr to migraine, considered this phenomenon, which is common to neuralgia and migraine, as due to tetanus of the muscular coat of the vessels. In the trifacial form, gentle friction, kneading, and pétrissage over the side of the jaw and malar region, with gentle circular friction with the thumbs, beginning at the median line above the orbit and proceeding upward, obliquely, and outward, are usually well borne from the first. With increased toleration this may be followed by percussion with the finger-tips or a vibrator. By these manipulations the temperature is raised and the vessels that were hard and contracted become full and bounding, while the pain of the paroxysm is greatly relieved and its return postponed.

The parts manipulated should always be covered to conserve the warmth gained by the massage. In this form and the occipital form

the vibrator should be employed with light, quick stroking movements of the brush attachment, the treatment never continuing more than thirty seconds over one area excepting at the point of exit of the cranial nerves, when the brush or soft-rubber attachment may be used for two or three minutes with light pressure. In neuralgia some form of percussion and compression has been popular since the time of Balfour, of Edinburgh, nearly one hundred years ago, and Mortimer Granville's "percutors," which foreshadowed the modern vibrator.

Intercostal neuralgia readily yields to friction and percussion along the course of the nerves, in addition to vibration over the nerve roots, using the ball attachment and deep pressure for two or three minutes. Care must be taken to avoid any danger of nerve bruising from undue violence. The inhibition of pain is, of course, temporary, and when the neuralgia is associated with anemia, the constitutional treatment for that condition should not be neglected.

Occupation Neuroses.—Scrivener's palsy has become comparatively rare with the increased use of the typewriter, but exhaustion neuroses are frequent among piano-players and violinists, baseball-pitchers, and telegraph operators.

While no morbid anatomic change can be made out, this trouble appears to be the result of an exhaustion or overexcitability of the centers controlling the muscular movements most involved. The symptoms are cramps and spasms of the muscles, weakness and debility, extending even to paralysis, tremors, a feeling of great tiredness, with acute shooting pains, and sometimes a subacute neuritis, with pain, numbness, or tingling in the fingers. These conditions run at best a chronic course, which can be greatly shortened if perfect rest from the habitual movement and daily massage and manipulation, with simple gymnastics, be applied.

Infantile Paralysis.—The outlook for complete recovery of a group long paralyzed is bad, but a gradual restoration of power may go on throughout several years, and Jacob Bolin reports the return of contractility after ten or twelve years. If these cases are neglected, however, the atrophy becomes extreme, the growth of the bones is retarded, and unopposed active muscles contract and produce deformities.

In examining these cases care must be taken to distinguish muscular action from the force of gravity and also to carefully isolate the useless muscles from the accessory groups that may partially replace them.

Treatment may be begun as soon as the child can bear friction of the affected part.

It should consist of massage of the affected region from the periphery to the center, friction with deep kneading, and stroking to increase the circulation, which is always defective, as shown by the constant subnormal temperature.

A splint may be necessary to prevent overstretching of the paralyzed muscles from the unopposed action of their uninjured antag-

onists. Whenever any voluntary action remains in the affected muscles, it should be carefully fostered by gymnastic exercises, to train the patient's will-power and concentration.

Every means must be used to maintain the nutrition of the muscles, so that recovery of the injured centers in the cord may find well-nourished muscular tissue on which to act. Flannel bandages or a covering of rabbit skin should be kept on the limb, so that its temperature may be continually kept equal to or above its fellow, and the muscles, bones, and joints given the increased blood-supply.

The technic of massage may be taught to the mother or nurse, to be continued daily at home, in addition to the less effective stimulation by electricity, and it should be persisted in throughout the entire period of growth, where necessary, accompanied by frequent examinations and measurements.

Neurasthenia.—Hysteria and neurasthenia require massage and resistance movements for their complete management. In Weir Mitchell's treatment for these affections he first counteracts the evil effects on the digestion of overfeeding and continual rest in bed by massage and gymnastic movements, to reaccustom the patient gradually to the muscular tasks of daily life.

His custom is to begin with a general massage after the first few days of milk diet, the hour chosen being midway between two meals, the patient remaining in bed. The operator starts with the feet, continues the manipulations up each leg, then to the muscles of the loins, spine, abdomen, and chest. The entire treatment lasts about half an hour, and is gradually increased up to one hour, followed by an hour of rest. This is continued for at least six weeks, and then half an hour is devoted to massage and the other half to movements of flexion and extension of the limbs and trunk, with resistance. In the less severe cases confidence is put in the more active forms of exercise, and cases derive the greatest benefit from an active outdoor life, in which camping, swimming, walking, riding, and wrestling form a great part of the day's program.

Exercise should be made as simple and interesting as possible, the object being to improve the nutrition to the utmost without unduly exhausting the attention or overtaxing the coördination. For this reason exercise demanding skill and concentration, like fencing, should be avoided.

Stammering.—Exercises of skill are employed almost exclusively to correct such disordered coördinations as stammering and stuttering, where the utterance of intelligible speech is hindered or prevented by convulsive and disorderly contraction of the muscles of respiration, phonation, or articulation.

Stammering occurs in about 1 per cent. of school-children. Although accurate statistics are hard to get, the Germans show about 1.22 per cent. in the schools, whereas Hartwell's statistics show about 0.78 per cent. among the children of Boston.

Stammering is exceedingly contagious in a class, and rapidly

spreads among school-children, making schools, according to Melville Bell, veritable nurseries of stuttering.

It has been attributed to the forcing of their education before the brain is sufficiently developed to govern the power of vocal utterance, so that a course of treatment would begin with gymnastic exercises, such as are described on page 340, for the breathing muscles, the first to function in the development of the child, while, later on, the muscles of phonation, and, lastly, those of articulation, are trained. Treatment would thus be based on the preliminary development of the fundamental and intermediate mechanisms, ending with the finest and most specialized coördinations.

Audible speech is caused by the blast of air driven from the lungs by the muscles of expiration through the slit of the glottis, bounded by the vocal cords, whose approximation is varied by the laryngeal muscles, into the mouth, where it is formed and modified by the muscles of the palate, tongue, and lips. The complete production of speech, then, is effected by a coördination of muscles in the chest, throat, and mouth respectively.

Hudson Makuen lays special emphasis on the difference between

Fig. 155.—The points of contact between the tongue and palate in the formation of the sounds L, R, and K (Hudson Makuen).

ordinary passive breathing and the breathing of voice production, or "artistic breathing," the function of passive breathing being simply to aërate the blood and eliminate waste-matter, while breathing for voice production is to set the machinery of the voice in motion and to control this motion as a definite voluntary muscular process.

The first muscular act in breathing for voice production is a slight inhalation, putting the respiratory muscles and the thorax into an active position. He finds that nearly all speech defectives fail at this point.

When this is done properly, the column of breath raised upon the diaphragm is ready for its impact against the vocal cords—an impact which must be made with the greatest nicety and control. This movement of expiration for voice production he attributes to the depression of the lower ribs by the diaphragm—a muscle of inspiration in ordinary respiration, whereas in the "artistic" breathing needful in voice production it becomes a muscle of expiration, not only by preventing the pulling up of the ribs, but by pulling them

downward and inward. Proper coördination of the intercostal and abdominal muscles in addition to this action of the diaphragm is, of course, essential to the production of good tone.

Treatment of stammering would then be begun by the training of this respiratory coördination by itself, which is done by articulating a series of syllables, using for each a single expiratory effort. The muscles that control the vocal cords are also trained by exercises; and the coördination between the muscles of expiration and the laryngeal muscles are then trained to act together, since many stammerers vocalize at the wrong time, there being no column of air ready when the cords are in the right position, or vice versâ.

The pharynx, the palate, the tongue, and the lips, organs of articulation which mold the voice into speech, are also controlled by voluntary muscles. Where there is any organic defect in them, such as shortening of the muscular fibers, cleft palate, or harelip, this must be corrected, and the rest becomes a purely educational process.

Care must be taken to distinguish between lack of development,

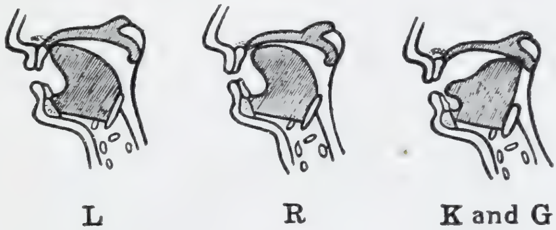


Fig. 156.—The position of the tongue in producing the sounds L, R, K and G (Hudson Makuen).

faulty habits, and disease in the speech center of the brain, for in the last class of cases the outlook is hopeless.

The entire treatment of functional stammering and stuttering is based on the physical training and coördination of the mechanisms of speech, the proper use of the muscles of respiration with reference to voice production, the training of the vocal muscles, and the education of the muscles of articulation.

Exercises are given to instruct the patient in the elementary sounds of the language, how to shape the lips, or where the tongue is to be placed, and this training requires patience and perseverance until the defect is finally overcome.

The success that has attended Makuen's clinic on speech defectives is in great part due to the care with which the breathing and vocal exercises are graded, and the excellence of his discipline in inforcing their accurate, thorough, and persistent practice.

The high-pitched, falsetto, or eunuchoid voice, which occasionally occurs in men otherwise normal, can be corrected, according to E. E. Clark,* by a course of vocal gymnastics and singing exercises, beginning

* Medical Fortnightly, St. Louis.

with a note of high pitch and then singing down the scale until the lowest possible note on the register is reached. The voice is then kept at this pitch, and the low notes are repeated ten or fifteen times. The patient is then taught to read aloud in the deep tone secured by singing his way down the scale. Makuen secures the same result by training the patient to lower the position of the larynx during phonation.

Chorea.—Chorea is a disturbance of coördination characterized by irregular involuntary contraction of the muscles, accompanied by psychic disturbances, found mostly in young children, the proportion of girls to boys being 3 to 1.

The treatment of the acute attack consists of rest, isolation, and tonics. Where the jerky movements have abated, the application of general massage is of value, and the importance of gymnastic exercise cannot be overestimated during convalescence.

When the acuteness of the attack has subsided, the treatment should be begun with massage for the first few days, followed by simple, slow, resisted movements, and later on by rhythmic exercises sufficiently active to tire the muscular system moderately. This

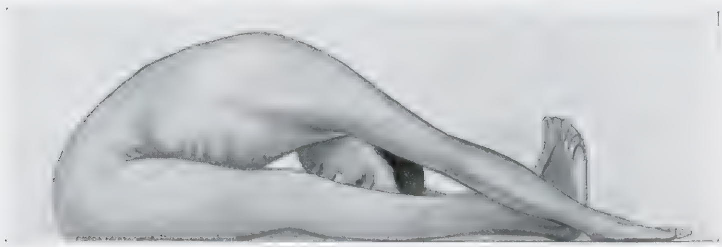


Fig. 157.—Hypotonia of the muscles of the pelvis and spinal column (Fränkel).

should be done with the patient by herself if possible, and any excitement or competition of class drills should be sedulously avoided.

The keynote of such treatment is the rhythmic repetition of simple movements to overcome the irregularity of the twitchings, and great strain or fatigue on the attention of the patient should be eschewed.

The practice of simple dancing exercises to music is of the utmost service, emphasizing the rhythm and taking away the mental strain necessary to follow movements done to command.

Locomotor Ataxia.—Locomotor ataxia, or tabes dorsalis, is a degeneration of the posterior roots and columns of the spinal cord, produced by exposure to fatigue, cold, syphilis, or some other acute poisoning of the nerve tissue.

In reading the literature of the subject one is struck by the multitude of theories and the inadequacy of any one of them to explain many of the symptoms.

Men being more exposed to these fatigue influences than women, we would expect to find its frequency greater among them; and the

proportion is actually about 10 to 1, and James Stewart has noted its frequency among lumbermen who have lived a hard life in the logging camps during the winter and spring months.

The motor symptoms are first noticed as increased clumsiness, especially in the dark, or difficulty in maintaining the equilibrium when washing the face with the eyes shut (Osler). When the patient stands with feet together and eyes closed, he sways and may even fall if the surgeon does not steady him (Romberg's symptom). On turning quickly he is apt to fall. He leans upon a stick in walking, the eyes fixed on the ground, the body thrown forward, and the legs wide apart. The leg is thrown out violently; the foot is raised too high and is brought down with a stamping movement on the heel. In the arms it may be first noticed through his difficulty in buttoning his collar or in other simple acts.

Fig. 158.

With comparatively advanced ataxic symptoms he shows little alteration in the size, strength, or nourishment of the muscular system. There is, however, always present in a typical case, along with certain sensory disturbances, hypotonia, or lack of muscular tone, which allows the stretching of muscles and joints far beyond their normal range of movement (Frenkel). This may be associated with flabbiness of the muscles, but it has no connection with their actual strength, which is seldom impaired.*

While ataxia is the only symptom that can be reached by exercise, it is frequently sufficient to keep a patient bedridden when his other symptoms are not severe enough to interfere with his regular course of life.

The exercise treatment is based on the possibility of educating the impaired central nervous system, and reëstablishing the lost or enfeebled coördination and sensibility. The symptoms against which it is directed is a motor disturbance, which has its origin not in a diminution of the muscle's motor power, but in a loss of sensibility in it, and it is based on the capacity of the neuromuscular system for education so long as the motor apparatus itself is intact. It consists in relearning the ordinary movements, lost in consequence of a partial or total loss of sensibility, a task which in principle is identical with the acquisition by a healthy person of a complicated feat involving a nice adjustment of muscular action, such as juggling or balancing. Reliance must then be placed mainly on exercises of skill, alternating with passive movements and massage, as a relief

* Fränkel, p. 46.

to improve the nourishment of the muscles without continuing the demand on the rapidly tiring will-power.

In attempting the simple movement of rising from a chair the tabetic patient usually forgets to draw the feet backward, and so finds himself unable to rise without assistance. He has thus to learn this simple coördination over again.

Movements of walking forward, backward, and to the side, with steps of measured distance, should next be practised. For this purpose the floor may be painted with black lines or with foot-

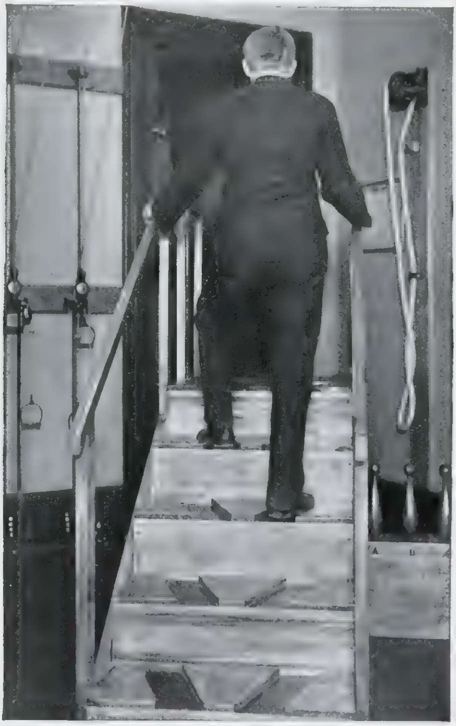


Fig. 159.—Dr. von Leyden's stairway, used for exercises to reëducate the lost coördination in locomotor ataxia cases (Pennsylvania Orthopedic Institute and School of Mechanotherapy (Inc.), Phila.). (Courtesy of Mr. Max J. Walter.)

prints at measured distances (Fig. 158). If lines be drawn zigzag on the floor, their continual change of direction makes this walking exercise much more exacting to the patient, and an irregular pattern on a carpet has been used for this purpose.

When these simple movements have been mastered, walking up and down stairs with the use of a bannister should be practised. A special stairway designed by von Leyden has two bannisters, and the steps are cut so that the foot must be placed down accurately at each step (Fig. 159).

The greatest precautions must be taken to prevent the patient from falling in this exercise and so becoming timid or discouraged. A belt with a handle or strap attachment should be placed about the waist, and an attendant should always be ready to catch him if he shows signs of losing his balance. Exercise of the lower extremities can be carried on in bed, where the disease is too far advanced

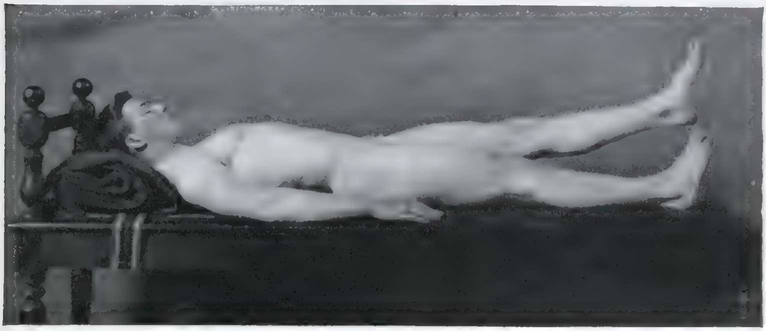


Fig. 160.

to permit of walking or standing. He is told to touch the great toe of one foot with the heel of the other (Fig. 160), then to run the heel upward along the front of the shin to the knee (Fig. 161), and back again. Another exercise is the placing of the heel of either foot in notches cut in a board, as shown in the illustration (Fig. 162). If

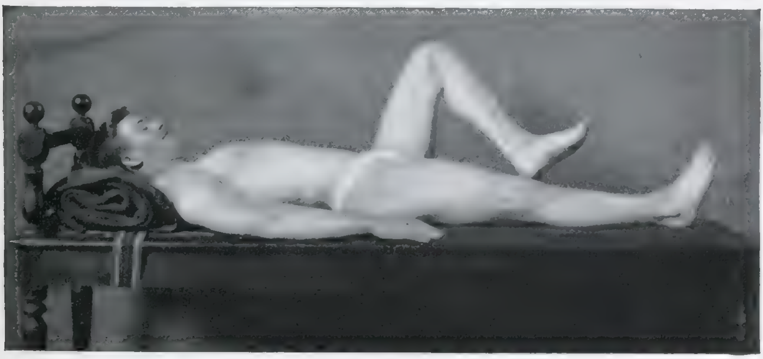


Fig. 161.

the patient be seated in front of a set of movable pins, he can exercise by kicking them in turn, the attendant naming the one that he must touch with his foot (Fig. 163).

Simple movements such as these will cause rapid exhaustion, and the pulse-rate must be carefully watched, and the exercise stopped short of fatigue.

The upper extremity may be trained by taking a wooden block about eighteen inches long and triangular in section, so prepared

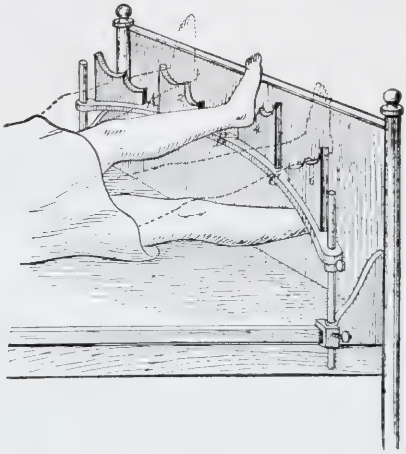


Fig. 162.—Notched board (Fränkel).

Fig. 163.—Dr. von Leyden's ten-pin arrangement, used for the reëducation of lost coördination in locomotor ataxia cases (Pennsylvania Orthopedic Institute and School of Mechanotherapy (Inc.), Phila.). (Courtesy of Mr. Max J. Walter.)

that one edge remains sharp, a second beveled off, while the third has a curved groove. The block is placed on a table in front of the patient,

in a position indicated by the drawing (Fig. 164), with the grooved edge up. He is requested to draw the point of a stout pencil or pointer along the groove from the farther end of the block toward him, at the same time holding his fingers and wrist-joint perfectly stiff. The object of the exercise is to teach him to keep his arm raised in a definite position, and to make simple excursions in the horizontal plane.

This exercise is by no means easy, especially when the pencil has to be held with the slightest force. At first it will often leave the groove, but with practice its progress becomes more steady, although scarcely ever free from wabbling.

It is usually a great surprise to a patient on his first examination to find that he is unable to place his finger to his nose with the eyes closed. This simple exercise may be practised and varied in numerous

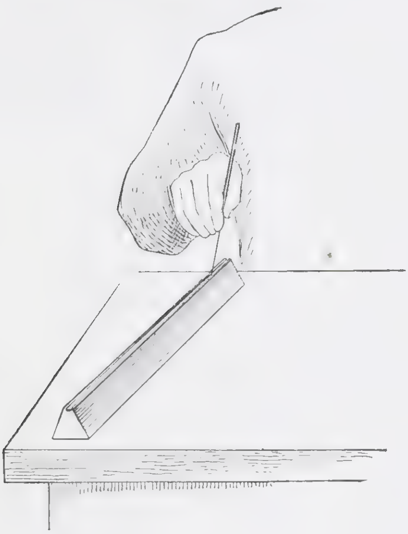


Fig. 164.—Triangle block for the hand coördination (Fränkel).

ways. Fränkel uses a perforated board (Fig. 165), the tip of the forefinger being placed in the numbered hole called out by the attendant. It can be made more difficult by having him insert pegs into the holes.

When this coördination is sufficiently improved, he may advance to the catching of colored balls swung from a horizontal bar and caught on the swing (Fig. 166); and he may be set to copying diagrams with a pencil. As soon as he shows signs of flagging interest, one task should be replaced by another.

Along with these set exercises he should be trained in the useful operations of dressing and undressing himself, helping himself at the table, using pen and ink, and other procedures that come up in the course of the day.

The exercises are useful only when the attention is fully con-

centrated on them. This necessity for concentration and the excessive muscular exertion required to perform simple acts, the fear of accidents, and the annoyance which he feels, especially at the

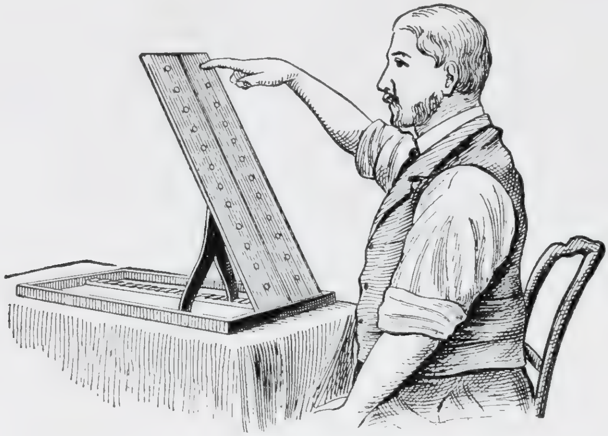


Fig. 165.—Perforated board (Fränkel).

beginning of the treatment, because his limbs will not obey orders, all combine to produce rapid and profound fatigue, and the practice of any movement should not be continued for longer than three or

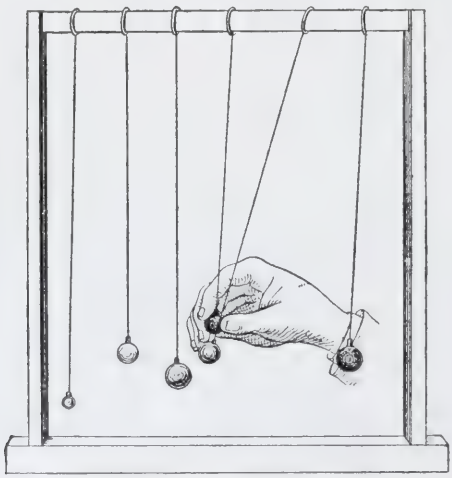


Fig. 166.—Colored balls swinging (Fränkel).

four minutes. In severe cases, where nutrition is impaired, one-half to one minute will be quite sufficient until he has become strong enough to bear the strain of long-continued practice, and no new

exercises should be begun until there is complete recovery from the excitement and fatigue of the previous one.

A tabetic patient has more or less completely lost the sense of fatigue, consequently in determining whether he is tired or not signs of inattention and the rapid action of the heart will be the most reliable guides. The pulse usually rises to 120, or even to 160, beats a minute, in direct proportion to the difficulty of the movement. It should be the routine practice, therefore, to examine the pulse at the beginning of the treatment and frequently throughout it, and to interrupt the work by a period of rest as soon as the pulse-beats exceed 150.

The interval of rest should last until the heart-rate approaches normal again, although in most cases the pulse will remain a trifle above its usual rate. If it becomes unduly frequent after slight exertion, it is a sure sign of tabetic cachexia, and such patients must be treated with the greatest caution.

The exercises are for coördination and not to increase the muscular power, therefore exercises requiring much expenditure of strength must be considered harmful.

Two periods of exercise a day are the average rule of practice. To go beyond that is to go into the danger zone, unless each séance be made short, and the patient is robust and determined to make rapid progress, in which case three periods may be given. In the morning he takes the movements designed for the recumbent position, which are the easiest. In the afternoon he may have fifteen minutes of walking exercise, with frequent rests. If the amount be properly regulated, each successive exercise should be followed by an increase in control, so that at the end of a period he should feel more fresh and vigorous than before starting. It is wise in some cases to substitute for one period a general massage or electric treatment, which has the great advantage of resting the patient's will and attention and improving the nutrition.

The unfailing certainty of the improvement and the fact that it is the improvement of a symptom caused by an organic lesion attaches unusual interest to this treatment. The hypotonia and sensory symptoms remain practically unaffected, although very frequently they seem to improve, probably because the patient's mind is diverted from them and directed to the acquirement of muscular skill; the improvement in muscular control, however, may remain for years.

The ideal result would be the restoration of the normal accuracy, control, and velocity of the movements, a result which Fränkel claims to have achieved in many cases. The restoration in locomotion is, however, generally sufficient to enable the patient to resume his usual business or profession, and this is all that may be expected.

In one case coming under my own observation, treated by John K. Mitchell at the Orthopedic Hospital in Philadelphia, and not by any means an unusual one, a miner from California who came bedridden and accompanied by an attendant improved to such an extent

that he was enabled to travel across the continent by himself and resume the active management of his mines. Such a result is so frequent as to be almost the rule.

The improvement is more or less lasting as the patient's occupation does or does not entail constant overstrain. If the ataxia does increase again, a course of exercise will once more bring it under control.

In giving a forecast of the progress to be expected in any case the natural disposition, the alertness, and the ability for muscular exercise must be found out and given full weight by the surgeon. The more skilful patients will make more rapid progress, and the best results are obtained among those who have been accustomed to work demanding dexterity, or who have been successful devotees of athletic sports, men who have lived a good deal in their muscles, and who have at one time had the muscular sense well developed.

Another important factor is the patient's personal courage. Apprehensive or cowardly patients will not risk the slightest movement without support or attention, and will have to practise for a long time before much definite improvement can be noticed. The longer and more thoroughly a course is continued, the more certain and lasting will be the improvement, and the closer will the patient approach to the normal in motor capacity and accuracy of movements.

The necessity of constant individual supervision is also recognized by all who have had experience in the giving of treatment by exercise. Every movement should be pushed to its utmost limit of efficiency. Many reported failures can be traced to the lack of intelligent personal direction. It is not sufficient to give the patient a vague outline of a course and leave its carrying out entirely to an assistant, however well trained, for in no department of medicine does the personality of the surgeon count for more. His presence should be an inspiration to his patient, and he should himself insist upon accuracy and precision throughout each movement, however simple it may seem to the casual observer.

HYDROTHERAPY AND BALNEOTHERAPY

By Guy Hinsdale, M.D.

General Hydrotherapy.—The good results of balneary therapeutics are greatly aided by the favorable influence of climate and the hygienic measures to which patients are held while under treatment at health resorts. Waters, externally and internally, climate suitable to the cases in hand, fresh air, suitable exercises, and a properly chosen diet are the cardinal points in the management of most chronic diseases. Pathologically, we are dealing to a large extent with disorders of metabolism. How far do we expect to correct defective metabolism by hydrotherapy? Can this be done satisfactorily at home? It can and must be accomplished at home, and very often without cessation of the usual occupations; but to obtain the full benefit and, in many cases, to obtain any benefit whatever, patients should be sent away. The ordinary means of hydrotherapeutic treatment are not obtainable in every city. City life is not conducive to systematic hygiene. The details of hydrotherapy demand a great deal of personal attention by the physician, the employment of trained attendants, and a certain experience which is acquired by constant practice in the measures employed. Patients who are difficult at home yield gracefully to the régime of a health resort properly conducted. The adoption of measures new to them, the example of others who are "taking the cure" amid attractive natural surroundings and free from the old associations, are a great help to both doctor and patient.

The secret of the "cure" lies in the unusual attention paid to the skin. Hitherto the patient has had tonics for the heart, stimulants for the liver, sedatives for the nervous system, very often hypnotics, alcohol, and artificial products, but the skin has been systematically neglected. Impervious clothing has robbed it of its proper tone; excretions are retained; it is coddled, and the other organs take up an additional load in consequence.

Few have a correct understanding of the *rationale* of the effect of baths in mineral springs. The general conception has prevailed that the mineral constituents of the water employed for the bath were absorbed into the blood, and the virtues of a given spring were in direct proportion to the quantity and the quality of the several ingredients. Undoubtedly this belief prevails widely among the people and also, to some extent, among the medical profession. It has come down from past ages and has been fostered by those who

are interested in mineral springs and who see the good results obtained by bathing in particular waters whose composition is given by chemists with the utmost refinement of chemic analysis. We are familiar with the various labels designating an ingredient determined in grains to the third and fourth decimal place per gallon, and it is not surprising that since so much stress is laid upon these diminutive fractions by the analysts, a corresponding impression should be made on the minds of those who use the waters.

We are not discussing at this time the internal uses of mineral waters which rest upon a totally different basis, but we wish to show that, in regard to bathing, we ought to place the credit where it properly belongs. Take a man with an uninjured skin, and do as Röhrig did, put him in a bath containing potassium iodid, the water being at 95° F., and the duration three-quarters of an hour: no iodin appears in the urine. So with potassium ferrocyanid, potassium nitrate, ferrous sulphate, and ferrous carbonate—all salts of the freest solubility and capable of easy recognition in the excreta.

The experiments of Stas upon himself corroborate these results. He subjected himself on three successive days to baths of 86° to 90° F. (30° to 32.2° C.) containing sodium arsenate in the strength of 50 mg. to the liter, but not the slightest absorption could be noted. Tests with potassium iodid also gave negative results. In commenting on such tests Dr. Simon Baruch, the leading exponent of hydrotherapy in America, says: "I do not claim that this negative result militates against the general impression that such mineral baths are exceedingly useful and effective therapeutically. On the contrary, we have here suggestive climatic and hygienic elements besides the local and general temperature effects. Just as the imbibition of mineral water strongly impregnated with purgative or other salts offers immediate evidence of their imbibition, there is, in the temperature effect of baths, similar evidence of action. The heat or cold conveyed by the peripheral cutaneous nerves to the central nervous system, and thence reflected through the motor tracts, is the really effective element in the mineral baths."

Take the famous hot springs at Aix, Baden, Gastein, Aachen in Europe, and in Virginia, Arkansas, and other localities in this country, where prolonged warm baths and massage during the bath are practised—all differing from one another noticeably as far as chemical analysis is concerned, and yet renowned the world over for their successful application for the treatment of gout, rheumatism, and allied affections; the marvelous results from bathing in these hot springs are attributable, in Dr. Baruch's opinion, not "to absorption of the mineral constituents of the waters, but to the excellent method of their application by experienced physicians." Intelligent physicians are endeavoring to combat these erroneous ideas, so deeply rooted in the minds of most medical men, not to speak of the laity. Dr. Baruch distinctly says: "In very rebellious cases of chronic

rheumatism and gout the douche-massage as practised at the Arkansas and Virginia Hot Springs in this country and at Aix-les-Bains and Aix-la-Chapelle is very useful. The mineral ingredients of the water are of little consequence, as has been shown above. The temperature and pressure under which it is delivered, and the skilful manner in which the douche is combined with massage, render this treatment extremely effective."

Dr. Heinrich Kisch, of the University of Prague and of Marienbad, says: "It may, therefore, be considered as established that the uninjured human skin is not permeable to water and different substances dissolved in it, even after long-continued exposure, and that absorption of fixed constituents through the skin does not take place in mineral baths. The skin of the bather is probably, however, permeable by the gases and the volatile constituents of the mineral water." It is, therefore, much more rational to hold that carbon dioxid and hydrogen sulphid are absorbed, while salts, such as carbonate of calcium, lithium, or magnesium, chlorid of sodium or potassium, are totally incapable of penetration.

On what, then, does the efficacy of the mineral bath depend? First of all, it is cleansing, the more so as it approaches an alkaline reaction. The secretion of the sweat-glands and the epidermal scales are removed, and this allows a more intimate contact of the water with the body.

Second: There is a stimulant effect on the skin by the chemicals dissolved in the water. These saline or gaseous constituents affect the peripheral nerves by tactile irritation, and thus produce effects on the circulatory and nervous system in a reflex manner. This is probably more definite when the irritation is produced by such gaseous contents as carbon dioxid; next in order would be the action of the denser saline waters, and least of all the mild calcareous alkaline waters.

Third: The thermic irritation which, it must be borne in mind, means the effect of cold as well as of heat; this is by far the most important.

Fourth: The mechanical irritation occasioned by mud-baths, moor-baths, and by any motion or pressure imparted to the mineral water in its application. If the water under pressure is distributed over the body of the patient in fine spray, it is quite possible that some of the contained minerals or gases may reach the interior of the body by inhalation. While the chemicals so absorbed would certainly be infinitesimal, the gaseous emanations from the mineral water may have a more appreciable influence.

PHYSIOLOGIC ACTION OF SALINE BATHS COMPARED WITH FRESH-WATER BATHS

Starting with the assumption that possibly saline baths exert a different action on the organism, Dr. Theodore Groedel II made a

great number of experiments bearing on this matter under the direction of Professor Rieder, in the Centralbad of the Munich Clinical Institute.*

Experiments were made on the respiration, pulse, blood-pressure, and body temperature in fresh water as well as with baths containing NaCl, KCl, and $CaCl_2$ of known concentration. The subjects were young men of twenty to twenty-four years, who were placed for half an hour in the same attitude, in an empty tub, as in the subsequent bath. They were covered with a sheet, and the necessary instruments were in place. Just before the beginning of the bath they were all carefully observed. The temperature was taken in the mouth; the blood-pressure was taken with the Riva-Rocci sphygmomanometer. Two competent observers were assigned to note the disappearance and reappearance of the pulse, so as to eliminate any personal factor. The rate of the pulse was recorded for a minute, and the respiration noted by a water manometer provided with a thin rubber tambour attached to the breast by a bandage. The tubs were then filled without any disturbance of the subjects, and measurements were taken for five minutes and repeated in five minutes. The apparatus remained unchanged in position during the entire period of the experiments, so that the readings were made under similar conditions. The baths were previously arranged so that they consisted of pure fresh water; salt water in strength of 3, 4, 5, 6, 7, 8, 9, and 10 per cent.; potassium chlorid, 4 and 8 per cent.; and calcium chlorid, 4 and 8 per cent. The atmospheric temperature of the bath-rooms was maintained at 20° C. (68° F.); that of the baths, at 35° C. (95° F.), which is an accepted standard for the indifferent bath.

A slight loss of *temperature of the water of the bath* was noted; without the subject in the bath it amounted in fifteen minutes to about 0.4° C. (0.7° F.); with the subject it varied between 0.3° C. (0.5° F.) and 0.5° C. (0.9° F.). The *body temperature* fell in the fresh water between 0.1° C. and 0.2° C. (0.2° F. and 0.4° F.), and in the salt baths from 0° to 0.3° C. (0.5° F.). The *respiration* record gave a variation of —1 and +1 in the fresh water, and —4 and +4 in the salt baths. The rate of the *pulse* was not, on the whole, affected when the salt baths were compared with the fresh-water baths; the extreme changes when in the salt baths were +4 and —8. The *blood-pressure* was altered from 0 to +3 mm. Hg in the fresh-water baths, and from —10 to +19 in the salt baths, the higher readings being obtained with the 10 per cent. sodium chlorid and the calcium chlorid baths. It was evident from these careful observations that the bodily temperature, and the frequency of the pulse and respiration were practically the same in the fresh-water as in the saline baths, while in the latter the blood-pressure was both increased and diminished. Robin found that *nitrogen elimination* was increased by salt baths, while Keller found it to be diminished.

We, therefore, see that non-gaseous baths of sodium chlorid,

* Berlin. klin. Woch., March 13, 1905.

potassium chlorid, and calcium chlorid, at different degrees of concentration and at an indifferent temperature, are not accompanied in their action on the healthy organism by an effect essentially different from that of fresh-water baths either as regards bodily temperature, respiration, or pulse-rate; the most that can be determined is a greater or less fluctuation of the blood-pressure.

Under similar conditions the following observers record that the body temperature undergoes no other variations than in fresh-water baths: Jacob, Lichtenstern, Taegener, Theodore Groedel II.

That the pulse-rate is unaffected: Trautwein, Taegener, Groedel II.

That it is lessened: Heyman, Stifler.

That the blood-pressure is increased: Trautwein, Stifler, Groedel II.

That the respiration is quieter and deeper: Heyman; rate unaffected, Trautwein, Groedel II.

Nitrogen elimination increased: Robin; diminished, Keller; after KCl baths, diminished; otherwise unchanged, Kostlin.

METABOLISM

This is generally appealed to in the explanation of the good results obtained by hydrotherapy. The effects of such measures on metabolism, as shown by an analysis of the urine, were recorded by Dr. Otto Folin and Dr. George T. Tuttle, of Waverly, Massachusetts. Nine subjects, including mental patients of good physique and nurses in the McLean Asylum, were given a uniform diet, adapted to the capacity of the individual, and containing a known amount of nitrogen; after this diet had been continued for two days the urine was collected for each twenty-four hours and subjected to an exceedingly careful analysis. After three or four days baths were given about as follows (for technic see p. 462): Hot-air cabinet, 174°–190° F. to perspiration; circular douche, 95° F. (35° C.), twenty seconds, pressure 26 pounds; fan douche, 85°–75° F., twenty-five seconds, 26 pounds; jet, 65° F., five seconds, 20 pounds. The treatment was varied for individual cases. These studies, contrary to expectation, failed to show any metabolic changes, although most carefully worked out on the basis of urinary excretion. We cannot help thinking that there may have been other evidences of altered metabolism beside those derived from urinary analysis alone. They were too brief to affect metabolism very much, and there was not sufficient alteration of temperature. Patients free to eat and exercise at will no doubt gain during hydrotherapeutic treatment. The general records of the McLean Hospital show that of 216 consecutive insane cases treated with similar baths, and on the usual diet, 168 gained in weight and 48 lost. The gain was from ¾ to 33¾ pounds, and the loss from ½ to 22½ pounds.

The experiments of Pospischil show that the rate of heat-production is increased in the cold bath by rigorous rubbing by as much as

* Amer. Jour. Insanity, October, 1904.

44 per cent., and this may to a great extent diminish the temperature-reducing effect. Short, cold shower-baths increase heat elimination from 25 to 66 per cent.; even more if mechanical friction is carried out. By as much as the temperature of the bath differs from the body temperature, by so much is there a strong resistance of the body to overcome the loss or gain of heat. Pospischil also found the flow of respiratory air to be increased nearly three times in the half bath. Increased vigor is undoubtedly the result of the procedure, but it should be remembered that if the water is at the higher temperatures, as from 80°–90° F., a corresponding increase in the friction is required to produce good circulatory reaction. By raising the temperature of the water and communicating heat to the body distinct effects on metabolism are produced. Carbon dioxid is exhaled at a much more rapid rate, and this is also true of the application of cold water.* Tissue changes brought about by cold baths are caused by an effect on the innervation of the muscles; in fact, all combustion processes in the body are referable to the muscles. A single hot-air bath may have little effect, but a series of hot-air or hot-water baths increases nitrogen elimination, urea elimination keeping pace with the excretion of nitrogen; and uric acid is also excreted in greater quantity. Elaborate studies of these metabolic changes have been made by many observers, and in connection with ordinary hydriatric procedures, the half-bath, the Scotch douche, etc. It is interesting to note that Hippocrates† stated that the elevation of temperature that occurs in connection with most acute infectious diseases is, within limits, remedial in purpose and effect, and this is a principle that we are just beginning to appreciate. It apparently follows that temperature-elevating baths may be beneficial in aiding resistance to infection, especially when followed by a short cold bath, by favoring the production of alexins and antitoxins. It seems to us, however, that cold baths are better, practically, in the infectious fevers; witness the brilliant results obtained by the Brand treatment of typhoid. That baths of such obviously different character may lead to very nearly the same physiologic result is one of the apparent paradoxes of hydrotherapy. This is recognized in practice, for if patients do not react well to the cold bath in typhoid, it is Dr. J. C. Wilson's practice at the German Hospital in Philadelphia to give them a bath at 110° or 112° F. A patient, convalescent from long illness, complained to Dr. Sidney Ringer that he feared he could not resume his usual cold morning bath. "Never mind," said he, "take a hot one." He did so, taking it very hot and getting out of it quickly, and carried this out every morning for several years after the illness. The stimulant effect was produced whether the bath were hot or cold.

The effect of the *Nauheim bath* on metabolism would naturally be expected to be most pronounced, consisting, as it does, of solid

* Confirmed by experiments of Liebermeister, Goldscheider, Röhrig, Zuntz, and Strasser.

† System of Physiologic Therapeutics, edited by Cohen, vol. ix, p. 250.

and gaseous elements in large quantity. Improved assimilation and tissue metabolism is evidenced by formation of fresh muscular substance. The area of the dilated heart is diminished, but its power and true value are enhanced. Superfluous fatty tissues and inflammatory residual products disappear; effete products are eliminated, and a loss of weight is commonly noted at the outset, but after this more substantial evidences of constructive metabolism begin to be noted, and continue long after the patient ceases to take the course of treatment provided in accordance with this system of hydrotherapy.

Dr. Paul Franze, of Bad Nauheim,* corroborates many other observers in this particular. He says: "Tissue metabolism is accelerated as in cold fresh-water baths, only more pronouncedly; and it is relevant to mention that researches as to the physiologic action of chalybeate baths rich in carbonic acid show that this gas chiefly promotes the metabolism of non-nitrogenous matter, while excreted urea is diminished relatively to its intake. Practically, this means that while our baths reduce superfluous fatty tissue, they facilitate the formation of healthy muscular substance. This, of course, is especially applicable to the effervescing Sprudel baths.† The acceleration in tissue metabolism, aided as it probably is by osmosis, promotes the absorption of exudations in the joints, pelvic and serous cavities. Nauheim baths are among the most efficient means of abolishing the residues of rheumatism and gout, of serous inflammations, such as pleurisy and pericarditis, and of inflammatory conditions of the adnexa of the female genital organs."

Turkish baths tend toward a gain in weight, but if the heating process is shortened and cold water is applied liberally in connection with the plunge the subject loses, because the loss of heat has to be made good by increased katabolism in the tissues.

The effect of baths on the blood-count has been carefully studied by Dr. Guy G. Fernald, who found that there is sometimes an increase and again a diminution in both the red and white cells, and sometimes more of one and less of the other. If the cold bath is prolonged, the surface vessels allow an irregular distribution of cells and plasma, owing to constriction of the surface capillaries by cold. Under strong contraction it is believed that the plasma may run on and leave the cells stranded. Dr. Fernald's observations are appended.

* The Physiological Action of the Nauheim Springs and the Indications for Their Use in Circulatory Disorders, Journal of Balneology and Climatology, July, 1904.

† Flechsig also states that the excretion of urea is diminished by carbonated baths.

Case.	Time.	Before the Bath.			End of Hot-air Bath.			Two Minutes After Douches.			One and One-half to Two and One-half Hours after Bath.			Bath.
		Red.	White.	Ratio.	Red.	White.	Ratio.	Red.	White.	Ratio.	Red.	White.	Ratio.	
I	10 A. M.	4,014,500	9,184	654				4,676,600	7,630	613				Hot air, 172° 3 m.; circular, 95°–90°, 50 sec., 32 lbs.; fan, 75°–60°, 30 sec., 32 lbs.
II	" "	5,253,000	6,360	826				4,817,000	7,440	648				Hot air, 186°, 8 m.; circular, 95°–90°, 45 sec., 30 lbs.; fan, 85°–65°, 25 sec., 30 lbs.; jet, 65°, 10 sec., 25 lbs.
III	" "	4,720,000	9,211	512				4,779,000	8,911	536				Hot air, 190°, 16 m.; circular 95°–90°, 1 m., 32 lbs.; fan, 65°, 30 sec., 32 lbs.; jet, 65°, 5 sec., 25 lbs.,
III	" "	4,785,665	10,600	451	5,047,242	8,584	588	4,555,410	8 972	500	4,658,841	7,875	592	Hot air, 188°, 10 m.; circular, 95°–90°, 1 m., 35 lbs.; fan, 70°, 30 sec., 30 lbs.; jet, 70°, 15 sec., 25 lbs
III	" "	4,881,841	8,666	563	4,648,007	9,892	470	4,673,905	10,444	447	4,530,937	10,346	440	Hot air, 190°, 11 m.; circular, 95°–90°, 1 m., 35 lbs.; fan, 70°–60°, 30 sec., 35 lbs.; jet, 60°, 15 sec., 25 lbs.
IV	" "	4,375,000	5,995	730	4,322,000	5,477	790	4,180,000	5,694	736				Hot air, 188°, 14 m.; circular, 95°–90°, 35 sec., 28 lbs.; fan, 85°–68°, 25 sec., 28 lbs.
V	" "	4,810,000	7,385	665	4,639,000	9,020	514	4,463,000	9,295	480	4,637,000	8,121	570	Hot air, 186°, 17 m.; circular, 95°–90°, 30 sec., 30 lbs.; fan, 70°, 30 sec., 30 lbs.; jet, 70°, 5 sec., 25 lbs.
V	" "	4,674,693	7,300	640	4,406,165	6,268	703	4,172,722	7,138	584	4,123,793	7,249	568	Hot air, 180°, 12 m.; circular, 95°–90°, 30 sec., 35 lbs.; fan, 65°, 30 sec., 35 lbs.; jet, 65°, 5 sec., 25 lbs.
VI	" "	4,713,661	9,102	511	5,067,165	8,584	581	4,987,254	7,638	651	4,995,523	7,462	671	Hot air, 180°, 8 m.; circular, 95°–90°, 45 sec., 30 lbs. fan, 70°–60°, 25 sec., 30 lbs.
VII	" "	5,600,114	5,968	938	5,100,741	5,368	950	5,455,961	6,182	880	5,594,170	8,666	645	Hot air, 188°, 12 m.; circular, 95°–90°, 40 sec., 32 lbs.; fan, 80°–65°, 30 sec., 30 lbs.; jet, 65°, 5 sec., 25 lbs.
VII	" "	5,328,630	7,058	754	5,069,035	6,867	740	5,029,385	7,583	676	4,883,824	8,121	601	Hot air, 187°, 8 m.; circular, 95°–90°, 45 sec., 32 lbs.; fan, 70°–65°, 30 sec., 32 lbs.; jet, 65°, 15 sec., 25 lbs.

EFFECT OF BATHS ON THE NUMBER OF RED AND WHITE BLOOD-CELLS

EFFECT ON BLOOD-PRESSURE

Every hot or cold douche calls forth an increase of blood-pressure, paradoxic as it may seem. Cold baths contract the capillaries of the skin; there is a slower but more vigorous contraction of the heart and consequent rise of pressure. Baths between 95° and 104° F. (35° and 40° C.) produce a primary rise; a secondary fall below normal; then a rise. Baths above 104° F. increase the pressure and also the pulse-rate, the pressure remaining high. In baths accompanied by mechanical excitation the pressure is augmented, but returns easily to normal.* It follows that in the application of an agent which affects the blood-pressure so noticeably care should be taken not to aggravate any state of the system that cannot bear such an influence.

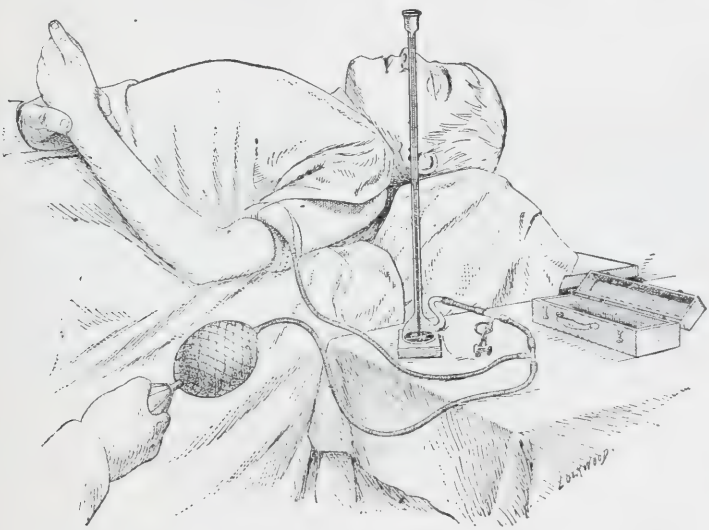


Fig. 167.—Sphygmomanometer of Riva Rocci. The author uses this instrument with the wider cuff of Theodore Janeway.

We should carefully note any weakness of the heart or blood-vessels, so as to avoid any accident, for undoubtedly accidents have occurred through neglect of this precaution. Dr. Osler has said that longevity is a cardiovascular question. To a majority of men death comes primarily or secondarily through this portal. For that reason the greatest care should be exercised at all times, but especially after middle life, to see that the circulatory organs are preserved and not weakened by sudden and unusual strain. One of the aids in the recognition of hypertension is the sphygmomanometer, as devised by Riva Rocci and modified by Cook, Stanton, Janeway, and Faught. It is perfectly practical, quickly used, and we have found it of great

* A full discussion of this subject is found in Dr. Baruch's "Hydrotherapy," third edition, p. 44 et seq.

value, supplementing the stethoscope in our estimate of the state of the vascular system.

In making a sphygmographic tracing of the pulse we can readily see the effect on the blood-vessels by the cold spray or bath. The pulse-rate is slowed, upward stroke is lessened, the dicrotic wave is less pronounced. The accompanying tracings, made by W. H. Riley, show this plainly. The upstroke is nearly vertical. It occurs during the dilatation of the artery, and is produced by the systole of the left ventricle. The line of descent is gradual, and corresponds to the diminution in diameter of the arteries, and, as it falls, the dicrotism appears. The height of the upstroke indicates the force of systole, but at the same time its height is restricted if the arteries are tense and rigid. A relaxed and dilated condition of the blood-

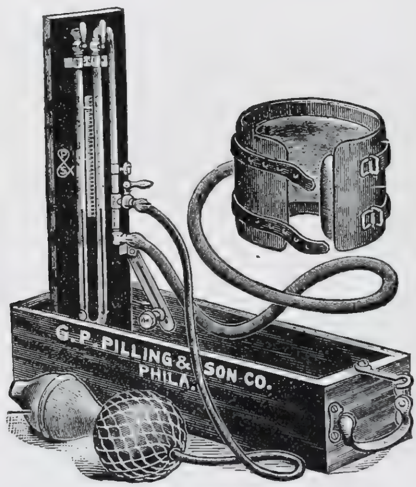


Fig. 168.—Faught blood-pressure apparatus.

vessels favors an increase in the length of the upstroke; and, conversely, arterial hypertension shows itself in a lower stroke and a less marked dicrotic wave. A powerful heart may be matched against a weakened artery. Of course, no harm results if the vessels are resilient and free from atheroma; the accelerated circulation, under favorable circumstances, restores the nervous system and promotes health.

A positive counterindication to such measures as the Nauheim bath, for instance, is any acute or subacute condition of the heart, or when, on the other hand, in chronic heart disease compensation is lost. In aneurysm much harm can be done, but these baths are permissible in moderate cases. I have recently given a course of artificial Nauheim baths to a patient with aneurysm of the arch of the aorta with a great deal of benefit. It is highly necessary to satisfy one's self that these conditions do not exist before prescribing the more

stimulating measures. Palpation and percussion of the heart and the use of the sphygmomanometer are good routine methods before using hydrotherapy. We know that the blood-vessels can bear a strain of

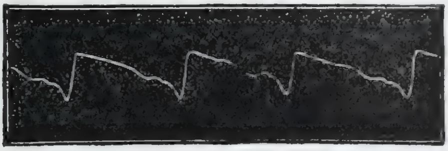


Fig. 169.—Tracing of a normal pulse (Sir Lauder Brunton).

140 or 150 mm. of mercury, as shown by the sphygmomanometer. H. W. Cook* has called attention to this subject: "Overexertion, either physical or mental, anxiety, overeating,—especially of meats,—

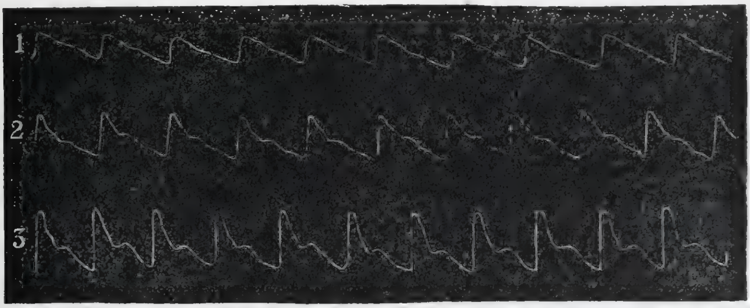


Fig. 170.—Tracings of healthy pulse with varying degrees of tension: 1, Tension is high, owing to the contraction of the arterioles from cold; 2 and 3, diminished tension from warm clothing, showing relaxation of the arterioles (Sir Lauder Brunton, after Marey).

and certain toxins—auto-, bacterial, metallic, or alkaloidal—produce a rise in blood-pressure and, therefore, added strain on the cardiovascular system, upon the integrity of which life and health so directly

Fig. 171.—Tracing from the pulse of a patient aged sixty-two with gouty kidney and an ailing heart. This tracing and the three following show the effect of Nauheim baths in increasing the cardiac force and dilating the vessels (Sir Lauder Brunton).

depend. This rise in blood-pressure, in part physiologic, becomes, when protracted over extended periods, a most pernicious and potent

* Trans. Medical Society of Virginia, 1904.

factor in inducing the train of cardiovascular diseases, which develop in clinical manifestations as cerebral apoplexy, aneurysm, arteriosclerosis, vertigo, angina pectoris, or nephritis. After the terminal

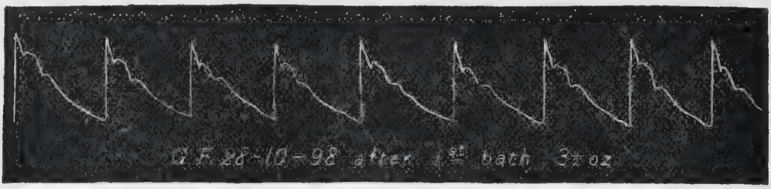


Fig. 172.—Effect of one bath (Sir Lauder Brunton).

affections have fully developed into clinical entities, it is too late to establish corrective treatment."

The effects of the hot-air bath, circular, and cool fan douche

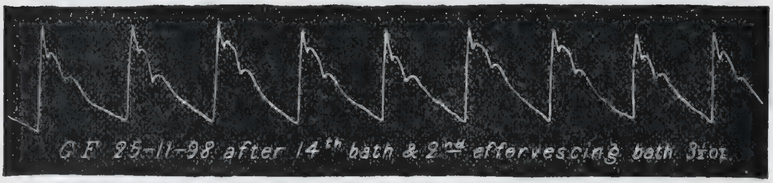


Fig. 173.—From the same patient (Sir Lauder Brunton).

have been recorded by Dr. George T. Tuttle * in the case of ten women, comprising nurses and patients in the McLean Asylum. The instrument used was that of Riva Rocci. The averages noted represent at

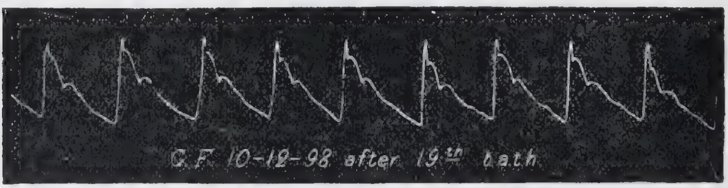


Fig. 174.—From the same patient after nineteen baths (Sir Lauder Brunton).

least ten observations. The table shows that there is a sudden fall of blood-pressure from 5 to 34 mm. of mercury, but this rises quickly to normal or above when the cool douche is applied. The temperature of the cabinet was 175°–190° F.

* Amer. Jour. Insanity, October, 1904.

BLOOD-PRESSURE IN MM. Hg.

Before the Bath.	While in Hot-air Cabinet.		After Douche. at 60°–65° F.
	Average.	Lowest.	
125	117	110	120
123	115	103	122
107	108	103	115
118	113	106	114
114	105	98	114
118	113	112	111
115	106	97	118
116	105	94	116
110	100	95	112
133	118	110	129
118	112	105	125
132	117	106	134
125	100	91	124
125	112	103	124
126	103	93	126
149	127	122	142
138	132	125	143
134	116	108	133
132	120	110	130
126	121	114	134

EFFECT ON THE RATE OF THE HEART

The most striking results are noted under the influence of the hot-air bath followed by cool douches. In the cabinet at a temperature of 170° F. we have noted a rise in the rate of the heart from about

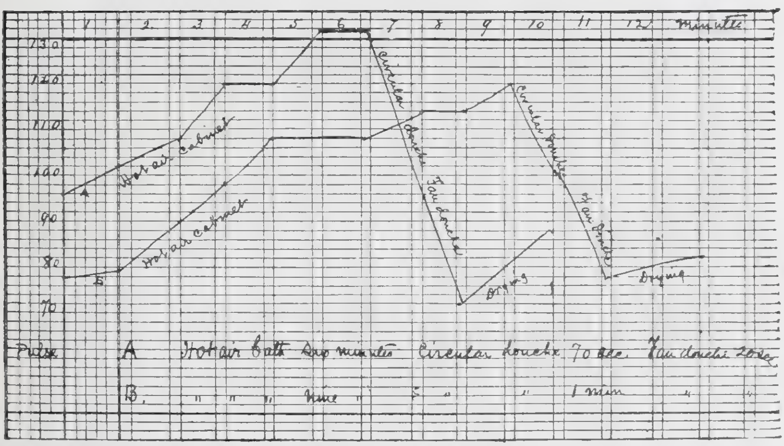


Fig. 175.—Showing the effect of thermic stimulus on the pulse.

Patient A.—Hot-air cabinet bath at 165° F. (73.8° C.), six minutes; circular douche, seventy seconds, 80° to 70° F. (26.6°–21.1° C.), two minutes. Drying and rest on the couch. Primary rise of the pulse to 130; secondary fall to 70.

Patient B showed a lower primary rise and in two minutes a fall from 118 to 76.

70 to 120; and, as the douche is cooled to 65° F., the pulse rapidly falls. We have noticed a drop of 60 beats inside of five minutes or less, and, as the patient is rubbed, the rate rises to a little above normal. Such changes in the rate and slight changes in the rhythm have been frequently noted and should be expected. They illustrate the quick response which the circulatory system makes to the stimulus of water applied in this manner.

EFFECT OF COLD UPON RESPIRATION

The cold douche produces at first short, gasping, respiratory movements, a sudden cold stream under high pressure producing the most marked effect. A full cold bath produces, after the first few movements, slow, full, and deep respiratory movement. The cold douche or spray accelerates the respiratory rate.

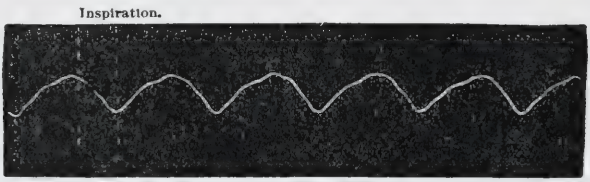


Fig. 176.—Tracing of the normal respiratory movements of a young man before taking a shower-bath at a temperature of 60° F. (made by Dr. W. H. Riley).

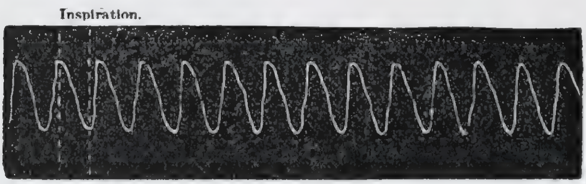


Fig. 177.—Tracing of the respiratory movements of the same while in a shower-bath at a temperature of 60° F. (made by Dr. W. H. Riley).

Technic

STANDARDS OF TEMPERATURE, IN DEGREES USUALLY ACCEPTED IN HYDROTHERAPY.

Bath	Water	Vapor	Air	
Cold	40°– 65°	....	....	
Cool	65°– 75°	....	....	
Tepid	85°– 95°	....	....	
Warm	95°–100°	....	....	
Hot	100°–110°	100°–115°	110°–120°	
Very hot	110°–120°	115°–140°	120°–180°	or more

The most important piece of apparatus in hydrotherapy is the bath thermometer. The trouble with most bathing attendants is that they do not rely sufficiently on a good instrument, easily read. It

takes young eyes and a good light to read the scale on the cheap bathing thermometer in common use.

It is generally believed and stated that heat can be conveyed to or abstracted from the deeper structures of the human body by external applications. This is probably true to only a very limited and comparatively superficial extent. Schultze has claimed that an ice compress can reduce the temperature 3.5° F. (2° C.) nearly one inch below the surface and 7° F. (3.8° C.) on the inner surface of the thorax. Esmarch undertook to measure the influence of cold on the body. He inserted a thermometer into a carious sinus in the leg and applied an ice-bag for nine hours, and noted a fall of 50° F. (10° C.). Similar results were obtained by immersion and also by irrigation with cold water. Schweinburg and Schlikoff claim a lowering of temperature when ice is placed on the surface and measurements are taken in the mouth, the vagina, the bowel, and the pleural cavity. When ice was placed on one side of the thorax, a lowering of the temperature in the opposite thorax amounting to 3.7° C. was noted. Winternitz, Silva, Hertel, and Kowalski have recorded similar experiments which show an undeniable temperature effect on the deeper structures when superficially applied. W. Gilman Thompson, of New York, in some unpublished experiments privately communicated to the author, arrived at very different results. He passed some long-stemmed thermometers into thoracic sinuses of patients who had been operated upon for empyema, and also into the female bladder. Very hot poultices were then applied to the external surface, and after these, ice-bags. The thermometers were never affected more than 0.125° F. Similar tests were made within the cheek with the same negative result. Dr. Thompson excised ribs of dogs, and fitted in glass windows with a double flange, so that the pink lung played against the window. Poultices applied to the external surface produced no temperature effect, although in all similar experiments on the cadaver the temperature was decidedly altered at once. In the latter case there is no layer of constantly moving blood beneath the poultice or the ice to quickly convey away the thermal units.

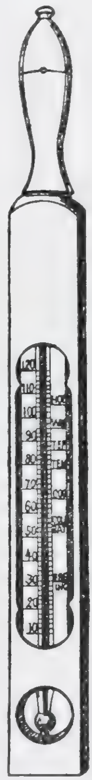


Fig. 178.—Bath thermometer commonly employed.

The obvious reason of the failure to influence the deeper structures of the human body is that the small amount of heat units contained in any ice-bag or poultice is ridiculously small in comparison with the

* Schweinburg, Handbuch der allgemeinen und speciellen Hydrotherapie, Wiesbaden, 1904, p. 16, 17.

total units in the body. Dr. Thompson points out that the bronchial and pulmonary vessels spring from such different sources from those supplying the external thoracic wall that there is no reason why they should be affected.

The fact that these applications relieve pain depends on an entirely different *modus operandi.* Neither should it be inferred that in pneumonia, for instance, there is no beneficial effect, notwithstanding that the external applications cannot reach the deep inflammation. (See p. 509.) Of course, the less vascular the parts, the more appreciable will be the effects.

In applying water therapeutically to the body we will mention some of the principal measures that experience shows to be reliable. Acknowledgment is made to Winternitz, Strasser, Baruch, Schweinburg, Buxbaum, Brand, Wilson, and others who have done so much to systematize the science and practice of hydrotherapy.

THE DRIP SHEET

This is one of the simplest and most useful therapeutic measures. The only things necessary are a tub holding ten or twelve inches of water at 100° F. (37.7° C.); a bucket of water at 75° F. (23.8° C.); a sheet; and an attendant. The patient stands in the warm water to prevent chilling, and the temperature of the room should not be less than 70° F. (21° C.). The sheet *dripping* with the water from the bucket is quickly applied to the shoulders and back. The attendant should hold the greater portion of the sheet, gathered into folds, in his left hand; the right hand holds the right-hand border of the sheet; after plunging it in the water he applies the upper edge of the right-hand border of the sheet under the right axilla; the patient holds his right arm firmly to his side, thus holding the sheet, while he turns to the left and winds the dripping sheet about him. When wholly covered from the neck down, it is tucked in at the neck and about the legs and vigorous friction is made, with slapping of the hands upon the surface. A dipper of water from 10 to 15 degrees below that used in the sheet is poured over the head and shoulders two or three times, alternately with frictions of the body. The entire process should then have occupied five or eight minutes. The sheet is then withdrawn; the patient is dried with soft towels, and friction is used with a warm sheet or towel to promote the hyperemia of the skin. A good deal of heat is abstracted in this process, and, while refreshing, it may be somewhat fatiguing when first applied. If the condition of the patient and the weather permit, it is a good plan to go out for a short walk. The bath is tonic, especially suitable for neurasthenics, hypochondriacs, melancholics, or for patients with anemia or pulmonary tuberculosis. From three to five minutes would probably be better at the outset in the latter affections. Only when antipyretic effects are desired are the longer periods, ten to fifteen minutes, required. In the latter baths the tonic effect is lost

and the sedative action is more prominent. The temperature of the water used for the drip sheet may be lowered 1° F. each day until 55° F. (12.8° C.) is reached.

THE COOLING WET-SHEET PACK

A linen sheet saturated in water at 70° F. (21° C.) should be wrung out slightly and wrapped about the patient, carefully applying close to the body and around each limb, and snugly about the neck. The patient may be covered lightly. In a few minutes, as the sheet warms, a second sheet, similarly prepared, is applied in place of the first one, and so on until five or six applications have been made at intervals of five minutes. Friction with the hand outside the sheet promotes cutaneous circulation, and the temperature of the febrile patient may fall one degree or more.

This pack is modified by opening up the sheet and sprinkling the body and the sheet with a sprinkling-can holding water at 40°–45° F. (4.4°–7.2° C.), allowing the patient to turn slightly to receive it on either side. Provision should be made to protect the bed and drain the surplus water.

In giving a wet-pack to a child or infant some modifications are necessary. Over a rubber sheet is placed a pad or thick flannel blanket on which the child is to rest. After removing all clothing the body is wrapped in a thick bath-towel, which has been moistened with water at 90° F. (32° C.). The legs and arms are allowed to be free. He is then covered with two or three thicknesses of blankets. The temperature is taken in half an hour. If no reduction has taken place, the towel is moistened without removing the child, with water 5 or 10 degrees cooler. The patient need not be disturbed any more than to turn him on one side and then on the other. The temperature of the pack may in this way be gradually reduced, as indicated by taking the temperature every half-hour. It is not usually necessary to use water lower than 80° F. (26.5° C.). If the patient's temperature is reduced to 101° F. (38.3° C.), the pack is removed and reapplied when required. In pneumonia occurring in infants and children this process is particularly suitable. The pack adds to the child's comfort, improves sleep, lowers the respiratory rate, and strengthens the heart.

EVAPORATION BATH

Place a mackintosh and blanket under the patient. Cover the patient, both extremities and trunk, with one thickness of gauze moistened in water at 115° F. (46° C.). Have the gauze fit the skin snugly. Fan the patient with a palm-leaf fan, and moisten the gauze, as evaporation takes place, with the water still at 115° F. (46° C.). One pint of water should be evaporated in fifteen minutes. A hot-water bag is placed at the feet and a compress on the forehead. To keep the water at 115° F. (46° C.), this basin should be placed in a larger one containing water of a higher temperature.

Cold applications, in the absence of ice or cold water, may be obtained by the use of nitrate of ammonium. To one quart of water add half a pound of the nitrate. If the water used has a temperature of 70° F. (21° C.), it will soon lose nearly 30° F. (16° C.) as the salt passes from the solid to the liquid state. This principle is utilized in the manufacture of artificial ice.

THE COLD RUB

A coarse linen sheet is soaked in water at 60°–75° F. (15.5°–21° C.), wrung out so as to hold less water than in the case of the drip sheet. It is wrapped around the patient; rapid friction is made, so as to redden the skin. After this the sheet is dropped and the patient goes out into the open air.

THE COLD BATH

The best time for the cold bath in fairly vigorous persons is before breakfast. Weak or delicate persons may take it in the forenoon. Chill, languor, or drowsiness coming on after the baths are counter-indications to their continuance. Tepid baths are then preferable. The water of the cold bath is usually drawn in a tub from the public supply, and varies, according to the season, from 40°–75° F. (4.4°–24° C.). The cold bath is the favorite bath of the Anglo-Saxon race. Every one is familiar with the determination with which the Englishman, wherever he is, insures his morning cold bath, and undoubtedly it has an influence in promoting his vigor and his well-known appearance of health. It is a rather curious fact, however, that the English, while devoted to bathing as a hygienic measure, have not shown a corresponding devotion to hydrotherapy as a science and a valuable department of therapeutics. The cold bath is counterindicated in advanced life and at any age when arteriosclerosis exists. Cardiac weakness, emphysema, and bronchitis in such cases are better treated by hot sponge-baths.

When water is used for defervescent purposes, it is wrong to begin with too low a temperature, to use too little friction, and to employ the bath for too short a time. In severe acute diseases the action of the water cannot be judged exclusively by its effect upon the temperature.

THE SO-CALLED "HALF-BATH"

This is really a shallow bath, the water reaching to the umbilicus; but its application involves the whole surface of the body. It is a powerful tonic when applied with water at 65°–75° F. (18.3° to 2.21° C.), and should occupy from three to five minutes. The tub is filled to a depth of five or six inches. The patient should enter from a warm bed or his circulation should be stimulated by exercise. As soon as he enters the water he rubs his limbs, while the attendant

rubs the chest thoroughly for a few moments with both hands and then takes the limbs in turn. The attendant repeats the rubbing of the various parts quickly once or twice more. The shallow water enables the attendant to get at the various parts more readily than in the full bath.

The half-bath or shallow bath is useful in cases of anemia and in many chronic diseases of the spinal cord. It is useful in cardiac affections, and usually suitable for asthmatic patients who are oppressed by the Turkish or Russian bath. It is useful in chronic affections of the stomach and in constipation. At the higher tem-

Fig. 179.—Half-bath with affusion (Cohen).

peratures it is suitable for cases of sciatica and all painful affections of the lower extremities and pelvis.

SPRAY BATH

Technically, the spray bath, designated by French clinicians, *bains a l'hydrofère*, consists in applying to the skin of the patient a continuously fresh layer of water in a finely divided state. A specially devised spraying apparatus is used which affords a strong mechanical impact to the skin, exerting a marked sedative effect on the nerves, removing secretion. Mineral waters with gaseous and solid contents are used in this way at European resorts.

This is practically a douche of very fine streams issuing from a large perforated rose nozle attached to rubber tubing, and may be applied horizontally or in any other position.

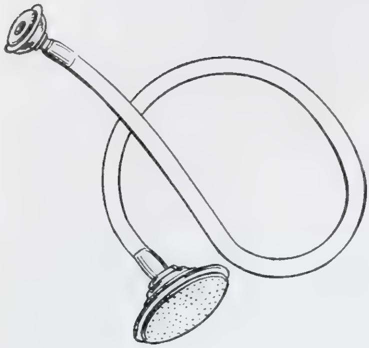


Fig. 180.—Adjustable spray with single attachment (Ashton).

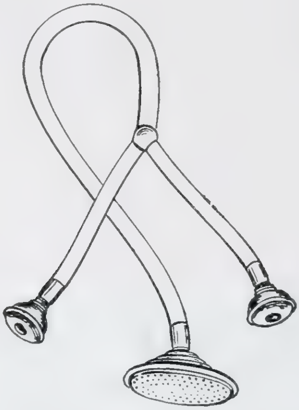


Fig. 181.—Adjustable spray with double attachment (Ashton).

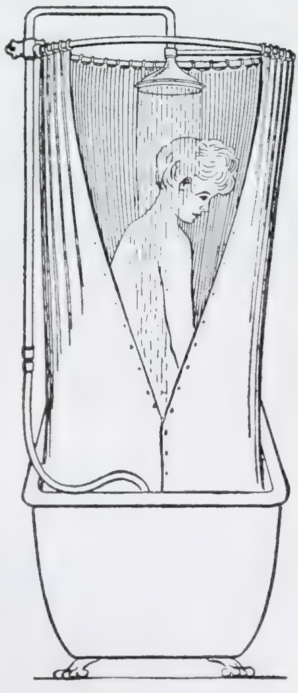


Fig. 182.—Adjustable shower-bath with a rubber-sheet attachment (Ashton).

Fig. 183.—Method of using a fountain-syringe and sprinkler as a substitute for a spray bath in the absence of running water (Ashton).

The spray bath is eminently suitable for treating sunstroke. The patient should be stripped and put on a cot covered with a rubber sheet and an ice-cap applied to his head. The water is supplied from the nozles in a fine spray, at the lowest temperature afforded by the public supply or from a supply cooled to a temperature of 55°–60° F. (13°–15.6° C.). When the rectal temperature reaches 103° F. (39.4° C.), he may be wrapped in blankets and made comfortable in bed, the process being repeated if the temperature rises, and in subsequent baths it may be possible to reduce the temperature to 101° F. (38.3° C.).

SPONGING

Before sponging a patient note first the exact temperature. Have water ready at between 80°–90° F. (26.7°–32° C.). Remove all clothing from the patient and have blankets over and under him. Put the basins, sponges, towels, etc., on a table nearby, so that it will not be necessary to leave the patient for any reason whatever. Commence at the head and sponge downward, exposing only one limb at a time. When the whole body has been sponged, the patient should be wrapped in a warm blanket and left undisturbed for an hour or longer. The temperature should be taken at the end of each sponging.

Cold sponging is better borne by sensitive patients if there is a preliminary sponging with tepid water—80°–90° F. (26.7°–32° C.)—before applying the water at 60°–70° F. (15.6°–21° C.). A hot bottle at the feet during sponging is comfortable to the patient, and may ward off a chill or tendency to collapse. After sponging, the body is to be dried and a night-gown put on.

DOUCHES

Douches may be applied to individual portions of the body, so that particular organs or other structures may be affected. The rain or shower, jet, the spray, the fan, or the filiform douche may be chosen, as the parts require, and they may be short, prolonged, hot or cold, or alternately hot and cold, and under greater or less pressure—from 10 to 35 pounds to the square inch.

Cold applications lasting one or two minutes are strongly stimulant, producing a vigorous reaction in most cases. The entire vascular and lymphatic systems immediately underlying the exposed parts are affected in proportion to the pressure under which the douche is applied. If no pressure accompanies the cold, the action is superficial, but may, in certain localities, produce reflex stimulation.

Hot applications allay pain or benumb the superficial cutaneous nerves. At a temperature of 90°–100° F. (32.2°–37.8° C.) they produce local and reflex sedative effects.

Rain or shower baths may be connected without very much expense with the supply of the ordinary bath-tub. They are supplant-

ing the tub-baths in the municipal bath-houses. (See p. 490.) The descending rain douche, in brief application and moderately low temperatures, causes a vigorous nerve stimulation and strong reaction. It accelerates metabolism, and promotes the circulation. It is especially applicable in nervous affections, functional disorders, such as neurasthenia and hysteria, neuralgia, paresis, disorders of nutrition, and in weak circulation when no organic changes in the heart and blood-vessels are present. It has a marked influence on heat-production and sweat-formation, for which somewhat longer applications are required. Tepid and warm rain baths have a sedative action, and are applicable, therefore, in very sensitive neurasthenic and hysteric subjects. Changing the temperature, now warmer and now colder, then quite warm, accomplishes much in torpid conditions, and enforces a good reaction, especially in anemia and chlorosis, because a good nervous stimulation is brought about without heat abstraction. Rain baths favor the action of the skin, and are applicable in many of its affections.

Cold Douche.—This is a single stream of water under pressure coming from a nozle of ¼ or ½ inch aperture, at a distance of 6 to 10 feet from the patient. The temperature may be regulated by valves which govern the mixing chamber, and may be graduated from 75° F. (24° C.) down to the coldest water supplied. It is a powerful stimulant, and useful for a tonic effect after the hot-air bath and circular douche. It is counterindicated in asthma. Paroxysms of asthmatic breathing may be induced. The sudden contraction of the pulmonary vessels restricts the area of blood subjected to oxidation in the lungs. The carbonic acid is not properly eliminated, and a sense of suffocation ensues. This is corrected as reaction occurs, and the secondary effects are powerful, tissue change being highly stimulated. Fatigue gives place to renewed energy, especially if the cold applications are preceded by heat and followed by vigorous rubbing. As a general thing, cold douches should follow hot applications, never the reverse, although alternate heat and cold are occasionally employed. They should always be preceded by wetting the head with cold water.

Aix Douche.—This is a combination of a warm douche with vigorous massage; it may be given by one or two attendants. It is rather too strenuous a measure for most patients, but may be used in refractory cases of gout or rheumatism.

Alternating hot and cold douches (called the *Scotch douche* for some unknown reason) produce distinctly exciting effects. They are not applicable to the head, the anterior chest, or the abdomen, but may be applied to the spine and posterior thorax and to the lower extremities. With temperatures alternating between 105° and 70° F. (40.5° and 21° C.), or possibly a few degrees lower, good results are obtained.

In applying a douche to the head it should be, as a rule, cold or cool, without pressure, as given from a dipper or pitcher, and the duration only a few seconds. The immediate effect is a dilatation

of the blood-vessels of the brain; if too long continued, a secondary contraction and chilling occur; it may be designated as an affusion, and is used in connection with the Brand bath, always at a slightly lower temperature, and repeated once or twice. It may be applied in mental disease, as in melancholia and hypochondria. In cases of insomnia, mania, and paresis, the water should not be less than 80° F. (26.5° C.) or more than 95° F. (35° C.). Douches to the head are generally inapplicable to women on account of the difficulty of drying

Fig. 184.—Aix douche as applied at Aix-les-Bains, France.

the hair. For women the full bath or the spinal douche is to be preferred. Great caution should be exercised in any case.

A wonderful differentiation of douches has been attempted. They are designated as lumbar, thoracic, shoulder, sternal, epigastric, hepatic, renal, splenic, perineal, plantar douches, and so on. The hot lumbar douche may be used in treating lumbago. Claims are made that the douche over the hepatic region at a pressure of 15 to 20 pounds and at a temperature of 65°–75° F. (18.5°–24° C.) for five

or ten minutes may relieve congestion. One of the patterns of sitz-bath tubs is provided with perforations giving a needle spray directly over the liver when the patient is seated. In this way the temperatures and pressures may be nicely adjusted. In cases of chronic enlargement of the liver the temperature should alternate between 105° and 70° F. (40.5° and 21° C.); in acute congestion only the higher temperature should be used. In hepatic colic alternating temperatures may be given, but in severe cases probably better results will be obtained by the use of hot compresses, frequently repeated.

Chronic malarial disease affecting the spleen and acute and chronic nephritis call for similar treatment. Renal calculus may be treated

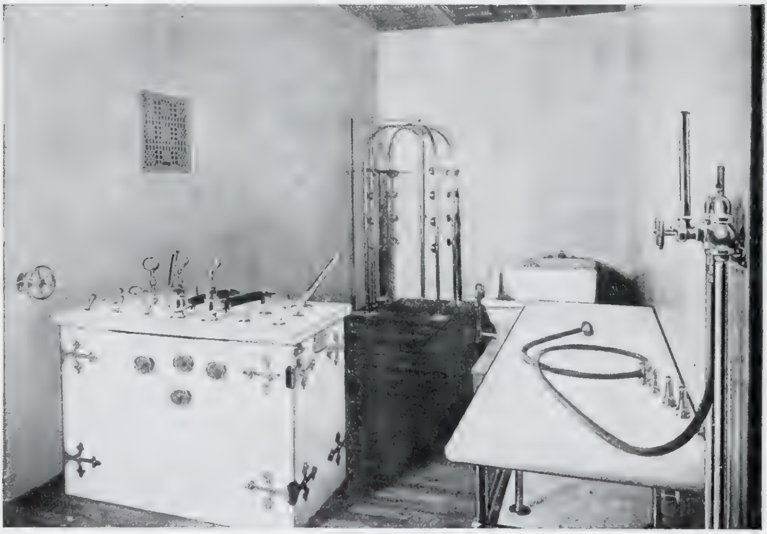


Fig. 185.—A modern control room showing control table, apparatus for rain and circular douche, tub (in the background), sitz-tub, marble slab for massage, and spray bath. Various nozles for the jet douche are shown. The walls are of Vermont marble. (Photograph from the McLean Hospital, Waverly, Mass.)

by very hot douches or compresses over the lumbar region. Every practitioner has seen good results from these measures. The author has never used a cold douche over the kidney, although it is claimed that it stimulates the flow of urine and relieves congestion. That the kidney can be reflexly stimulated by prolonged cold applications to the lower sternum is claimed by Beni-Barde. The small renal vessels are contracted, the pressure rises in the glomerules, and the urinary flow is stimulated. We are not aware that clinical evidence supports this view, although it appears to be a rational procedure.

Good results from douches are obtained in the treatment of chronic rheumatism, gout, and arthritis deformans. Exudates or

articular swellings respond to this form of hydrotherapy in connection with tub-baths, warm packs, and massage. The douche should be above the body temperature, and may be continued for five to ten minutes at a pressure of 12 to 18 pounds to the square inch. As usually given by the author, the temperature used is 104° F. (40° C.) at the pressures stated. It is an excellent preliminary to a tub-bath of eight, ten, or twelve minutes at the same temperature, and undoubtedly facilitates the action of the hot and dry pack. This is one of the features of the treatment of rheumatism and gout at The Virginia Hot Springs, where the thermal waters have the required temperature and where a constant pressure is supplied by gravity.

The control table, which has been perfected by the makers according to designs of Dr. S. Baruch, is a more convenient apparatus for administering all forms of douches at various pressures and at easily adjustable temperatures. (See Fig. 185.) The fittings are inclosed in a marble case. On the side where the operator stands are valves for controlling the pressure and for admitting water and emptying the pipes that are inclosed. On top are the valves which control the various outlets, the jet douches, the circular douches emerging from the uprights as seen in the background, the sitz-bath, and the perineal douche. Two thermometers indicate the temperature of the water delivered for use. Pressure gages show the pressure employed.*

AFFUSIONS

These are used in connection with the half-bath, the Brand bath, or as an independent measure. They are decidedly stimulant, and hence are valuable to rouse the unconscious patient. In cases of *sunstroke* they are remarkably successful. The patient, stripped or covered with a sheet, is placed on a cot protected by rubber. Dipperfuls of very cold water are then forcibly dashed on the patient from a distance of several feet. In severe cases a small stream may be allowed for a few moments to fall on his forehead. This is to be repeated every two or three minutes until the temperature falls to 103°–104° F. (39.5°–40° C.), when the patient is wrapped with blankets and surrounded with hot bottles. The latter is a complementary feature of the affusion, for sweating will probably ensue after a short interval in the warm pack, and the restoration of this function saves the patient.

* The J. L. Mott Company, of New York, The J. B. Clow Company, of Chicago, and The Hydrotherapeutic Apparatus Company, of New York, have installed control tables in a large number of institutions. It is too expensive for private use, but reference to the list which the author gives in his work on Hydrotherapy (W. B. Saunders Co., 1910) may prove useful to the practitioner in referring patients for treatment

THE WARM FULL BATH (95°-100° F.—35°-37.6° C.)

The Continuous Bath

A large tub is filled three-quarters full, and the patient enters and is fully immersed. His head is covered with a cloth wet in cold water. The room should be at a temperature about 80° F. (26.5° C.), and means should be at hand for maintaining the water at its initial degree of heat, as this bath is usually prolonged to ten, fifteen, or twenty minutes, or more as required. Indeed, the duration of the bath has been extended by Hebra, Zuschlag, and others to days and even months, the patients, some of whom suffered from extensive burns, bed-sores, pemphigus, and other skin diseases, existing in the continuous bath for remarkably long periods.* If continued for several hours, the patient may sleep in the bath, but he naturally requires constant attendance and special lifting apparatus and electric and other appliances for maintaining a constant temperature. For surgical and dermatologic purposes 100° F. (37.6° C.) is considered best. Mutton-suet, lanolin, or petrolatum applied thoroughly to the skin protects it from puckering and peeling. Although used in the Hamburg hospitals, we are not aware of the continuous bath being used in the United States to any such extent. Dr. Riess, of Berlin, thirty years ago, and later Dr. James Barr, of Liverpool, used the continuous bath extensively in typhoid fever, but it has never obtained very wide recognition outside of the dermatologic clinics of Hamburg, Berlin, and Vienna.

In formidable diseases like pemphigus, Kaposi shows that it relieves pain, reduces fever, and enables the patient to pass over the period of eruption when otherwise he might succumb.†

Prolonged warm baths are suitable for cases with bed-sores, compression myelitis, locomotor ataxia, and paraplegia, with paralysis of the bladder and bowels, inoperable cancer of the urogenital tract, obstinate cases of sciatica, and muscular and articular rheumatism. They have been advocated for chronic meningitis, hemiplegic contractures, and general hyperesthesia.

Hebra, junior, in 1877, reported upon 203 cases of various kinds treated by the continuous bath. Among these were 127 of severe burns, of which 71 died and 56 recovered. Excellent effects were noted in the relief of pain and the avoiding of infection, lymphangitis, pyemia, etc. Suppuration was slight; new skin rapidly formed, and the scars were better than under other treatment. Nine cases of pemphigus vulgaris were cured, and in six cases of foliaceous pemphigus life was prolonged and suffering materially alleviated. In one case of confluent small-pox complicated by pneumonia the five- to seventeen-day bath was applied; there was only moderate fever, the fever of suppuration was barely noticeable and the scars were

* One of Hebra's patients lived in a bath for over one year, and is said to have gained 14 pounds.

† Baruch, Hydrotherapy, second ed., p. 223.

good beyond expectation. Twenty-five gangrenous bubos out of 28 were healed, improvement appearing immediately after the treatment was inaugurated. Phagedenic chancres, phlegmon, gangrene of the skin, and other conditions were included in this series, and they were all serious cases. Riess reports remarkable improvement in cases of bed-sores, which occurred on patients suffering from disease of the spinal cord, and, further, made the unexpected discovery that the original disease underwent great improvement.

The various forms of meningitis, paralysis, delirium, and nervous agitation are stated to be amenable in some degree to the influence of the continuous bath, as well as obstinate sciatica and hysteria. Acute psychoses, epilepsy, and alcoholism have been treated with it by Kraepelin, Alzheimer, and Sander with good results. Maniacal excitement is said to respond to it with almost absolute certainty. In Beyer's Clinic of Mental Diseases at Heidelberg the improvement was so marked that even the great increase in the work required did not make it necessary to increase the number of attendants, improvement in the patients' symptoms rendered the nursing easier for them. Perdijo has lately reported excellent results with it in tetanus and in typhus, typhoid fever, measles, scarlet fever, and erysipelas. Rose and Riess also report good results. The benefits of the continuous bath are summarized by Grosse as follows:

First, it acts as a sedative upon the central nervous system.

Second, it influences the circulation in the sense of disincumbering the inner organs and directs the blood toward the skin.

Third, it favors the nutrition and healing processes in the skin.

Fourth, it augments heat withdrawal.

Fifth, it accelerates metabolism.

"The continuous bath constitutes an exceedingly effective remedy which, though apparently troublesome to administer in some respects, justifies expectation of good success where other less laborious methods fail."

Warm baths of short duration are valuable in all febrile affections in infants and young children, in cerebrospinal meningitis (see p. 510), and in acute mania and other excited nervous conditions. They exert a decidedly corrective, calming effect; the pulse becomes softer and less frequent; the respiration falls in rate. The peripheral arteries are dilated, and peripheral sensibility is blunted. Friction and other movements are not required in the warm bath. Cases of atheroma, angina pectoris, and other cardiac cases are not proper subjects for the warm bath.

Warm baths of half an hour's duration are very useful in amenorrhea and dysmenorrhea. In the latter case the temperature may be raised to 110° F. (43.3° C.).

HOT-WATER BATHING

Hot-water baths between 100° and 115° F. (37.8° to 46° C.) vary in their effect according to the temperature and duration. It usually requires a gentle gradation in successive baths to withstand baths of 105° F. (40.5° C.) or over, and people vary greatly in their sensitiveness to hot water. Different parts of the body vary in this respect. The feet, for instance, being much more sensitive than the hands.

The Japanese practice hot-water bathing more than any other people. It is said that they usually have the water at about 130° F. (54.4° C.). The head is bathed in hot water before entering the bath, which is prepared in wooden tubs, a common sight in Japan, where in Tokio alone upward of 400,000 hot baths are given daily. The temperature of the body rises to about 104° F. (40° C.) in the course of six to eight minutes, but returns to normal in about half an hour. Cold affusions are applied after the bath. This custom is common to all classes of Japanese. A porter with his load may become fatigued to the point of exhaustion; he drops it for ten minutes while he takes a hot bath at some public bath-house, emerges refreshed and strengthened, and goes on his way rejoicing.

THE TURKISH BATH

Well-equipped establishments are found in the larger cities. The objects to be attained by the Turkish bath are varied. As a hygienic measure the public employs it extensively without medical advice, and usually with decided benefit. Its effects are cleansing, refreshing, and stimulant to the circulation. It hastens recovery from the effect from alcoholic excesses better than any other procedure. It favors elimination through the lungs and the skin, and tends to reduce excessive weight. After disrobing the patient places a loin cloth about his body, takes a drink of water, either hot or cold, and enters a room with dry air at a temperature of 110° –130° F. (44°–54° C.). After ten or fifteen minutes perspiration appears. Superficial massage is then employed to induce perspiration, and sometimes a hot foot-bath, hot spray, or hot bath is employed. After perspiration is established he enters a room at 150°–200° F. (65°–93° C.) for a few minutes until perspiration is very free. After this the patient goes to a room with marble slabs, and, lying down, receives a rubbing with bare hands and finally a shampoo with soap. In this process the bathers use the loofah, or Egyptian fibrous sponge. Next the patient takes a cold douche at 65° F. (15° C.), or if perspiration is still rather free, he should have a rain douche, the temperature being reduced in from one to three minutes from 85°–75° F. (30°–24° C.). The next step is the swimming bath with water at about 60° F., or the patient may lie down until the skin is dry and the pulse is normal.

The great stimulus to the sweat-glands is the marked feature of the bath, and the secretion is increased tenfold during the hour's

treatment. By as much as the blood is drawn to the surface of the body by so much are the liver, spleen, stomach, and intestines relieved of any tendency to stasis. The Turkish bath is indicated in the treatment of obesity, alcoholic habit, diabetes, chronic dyspepsia the gout of

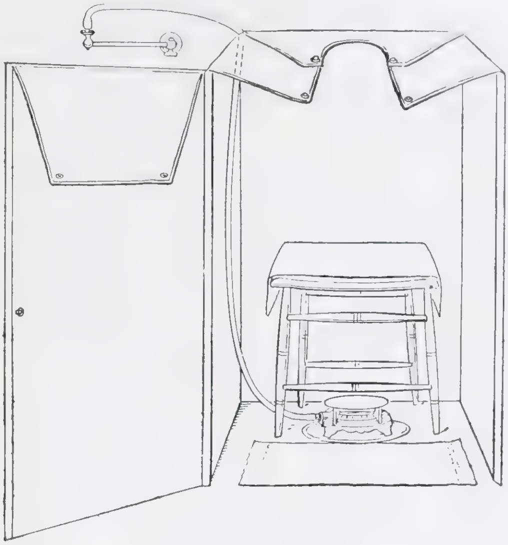


Fig. 186.—Ashton's method of arranging the interior of a Turkish-bath cabinet for home use.

corpulent persons; among neurasthenics and insane patients there are many who would be much better for Turkish baths; selected cases of neuritis and chronic myelitis may be treated in this manner. For anemia and chlorosis it is admirable. In ordering Turkish baths for

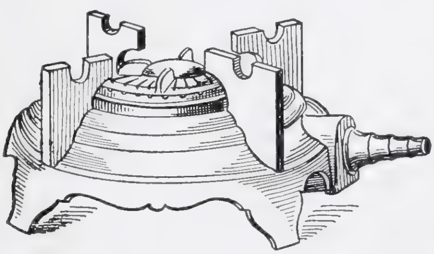


Fig. 187.—Round gas-stove for heating a Turkish-bath cabinet (Ashton).

gouty patients it should be remembered that heat will generally bring on acute symptoms in the affected joints.

Counterindications for the Turkish Bath.—In all cases of cardiac dilatation, tachycardia, arteriosclerosis, exophthalmic goiter, this bath should be avoided. Whenever, in cases of organic heart disease,

there is deficient or failing compensation, these baths may do harm. While some cases of nephritis are benefited, care must be exercised and the patient be under competent observation during their use. In advanced Bright's disease the Turkish bath is positively counterindicated.*

The Turkish bath is counterindicated in skin diseases accompanied by eruptions, on account of the excessive congestion of the skin induced. Vapor or Russian baths are preferable. They are to be avoided in cases with a history of apoplexy and in most pulmonary diseases.

THE RUSSIAN BATH

In this the patient lies on a marble slab in a small room filled with steam. He is rubbed at intervals by an attendant to hasten perspiration. The temperature of the room is lower than that of the Turkish bath—115°–120° F. (46°–49° C.), and the duration ten to twenty minutes. The presence of steam renders higher temperatures unbearable. After this the bather takes a shower of cold water, 60° F. (15.5° C.), or a plunge in a pool at the same temperature.

Sweating baths, on much the same principle, were formerly practised by some of the tribes of American Indians. One of their methods of treatment was the sweating bath. "These baths were literally earthen ovens into which the patient crept and around which heated stones were placed to raise the temperature. When the patient had remained under preparation for a certain time, he was taken out and immersed in cold water."†

The Finns are accustomed to take steam baths prepared by pouring water on heated stones, after which they rush out, dripping with perspiration, and roll in the snow to produce a vigorous reaction

TO APPLY THE VAPOR OR SWEATING BATH

Place a blanket and mackintosh under the patient; then wrap him in a blanket. Place a cradle over the patient, and cover it with mackintoshes, tucking them in well around the neck and fastening them securely at the bottom so the steam cannot escape. Put an ice-cap or cold compress to the head. A croup kettle or an ordinary tea-kettle with a long spout may be used to generate steam.

Let the steam come up gradually. Keep the patient in the bath for thirty minutes to one hour, as required. Watch the pulse and face and take temperature, pulse, and respiration in the bath. Give plenty of water to drink. Tea or hot lemonade may be given.

* See Winternitz, System of Physiologic Therapeutics, Philadelphia, vol. ix, pp. 262–67.

† See E. M. Ruttenber, Memorial History of the City of New York, p. 41; Benjamin Rush, Natural History of Medicine Among the Indians; Henry R. Schoolcraft, on The Indian Tribes of the United States, Philadelphia, 1851–55; Stoll, Reisen in Guatemala; Crevaux, Travels from Cayenne to the Andes.

THE HOT-AIR BATH

This is used as a preliminary treatment before applying douches. The entire body, with the exception of the head, is inclosed in a cabinet provided with steam coils. The head should have a cold turban, and the body may be surrounded with a sheet or not, as desired. The heat in these cabinets rises to 140°–180° F. (60°–82° C.), and, as a rule, free perspiration is produced in seven to twelve minutes. Portable cabinets for hot-air baths are sold at moderate prices by surgical instrument dealers.

FOOT-BATH

The hot foot-bath is the best and most important of the local baths. It is a popular method of treating a cold in its earliest stage, and is a valuable preventive measure. Hot water and a small tub or pail, and an additional supply of very hot water to reinforce the heat of the bath, are the only means required, although it may be desirable in some cases to add a little mustard, so as to invite the flow of blood to the feet and ankles. The temperature of the water may be gradually raised to 110° (43.3° C.), 115° (46° C.), or 120° F. (49° C.), and the duration may be ten or fifteen minutes. The depth may be 8 or 10 inches. After the initial chill of pneumonia it would be a proper procedure. Sprains of the ankle or foot, bruises, cramps in the leg, etc., are not only rendered much less painful, but hot applications prepare the way for massage and more permanent dressings.

MEDICATED OR MODIFIED BATHS

Sulphur baths may be prepared at home according to the following formula, which is sufficient for a bath of 30 gallons:

Precipitated sulphur	2 ounces
Sodium hyposulphite	1 ounce
Dilute sulphuric acid	½ "
Water	1 pint

The above ingredients should be mixed together, and then added to the bath. The following baths are occasionally ordered by dermatologists:

Bran bath—two to six pounds of bran. This should be tied up in cheese-cloth bags before being put in water.

Potato-starch bath—one pound of starch.

Gelatin bath—one to three pounds of gelatin.

Linseed bath—one pound of linseed in bags.

Alkaline bath—2 to 10 ounces of sodium bicarbonate or 2 to 6 ounces of potassium carbonate, or 3 ounces of borax.

Alum baths, one pound (500 gm.) to each bath (1 : 1000 solution),

are used at the Johns Hopkins Hospital to prevent skin infections in the course of typhoid fever.*

A modification of the **warm mustard bath** has been recommended by O. Heubner.† He has used it with great success in the capillary bronchitis of young children, and in the suffocative attacks which are marked in weak, rachitic children. About three pints of warm water are placed in an open vessel, and one pound of mustard meal is added and stirred until the thin mixture gives off the irritating fumes which cause smarting of the eyes. Then a linen cloth is taken of sufficient length to cover the child. This is saturated with the mixture, wrapped about the child, who is then covered with a woolen blanket reaching to the neck. After ten or fifteen minutes the child will complain of discomfort, and, as the wrappings are removed, the skin shows marked reddening. The child is then washed in warm water and is placed in an ordinary warm wet-pack and allowed to remain for one or two hours. This produces diaphoresis. After the pack the child is put in a warm bath which is gradually cooled. He is dried and allowed to remain quiet the remainder of the day. One advantage of this method is that the irritating fumes of the mustard are not inhaled, and that the reaction is more perfect.

"NAUHEIM" BATHS; CARBONATED BATHS; ACID BATHS (KISCH); EFFERVESCING BATHS

This form of bath depends on the presence of carbon dioxid with other chemicals, principally sodium chlorid and calcium chlorid in various degrees of solution. The natural baths are given *par excellence* at Bad Nauheim, in the Grand Duchy of Hesse, in Germany, near the southern foot of Taunus Mountains. The growing popularity of Nauheim is shown by the presence of 35,000 visitors in 1908,‡ but the greatest tribute to their efficacy is a wide-spread effort to prepare these baths artificially and avoid the long journey to Nauheim. The class of cases for which the treatment is sought renders it all the more desirable that the forms of treatment practised at Nauheim be provided, if possible, at home. Aside from the associated forms of treatment, such as resisted (Schott) movements, graded walks, diet regulations, and the benefits of climate, the baths are given at Nauheim according to a gradual increase in strength as regards solid and gaseous contents. This is a distinguishing feature. The temperatures of the three springs used at Nauheim are 85° F. (29.5° C.), 90° F. (32.5° C.), and 95° F. (35° C.). The duration of the baths is short—four to ten minutes, as a rule. The three types of baths are as follows:§

* "Alum Baths in Typhoid Fever," by Thomas R. Boggs, M.D., Jour. Amer. Med. Assoc., June 25, 1910.

† Therapie der Gegenwart, January, 1905.

‡ In 1907, 419,277 baths were given.

§ See description by Paul C. Franze, M.D., in an address before the Hunterian Society of London, March 23, 1904, and in the author's work on Hydrotherapy, p. 310.

The first and mildest type, the so-called *thermal baths*, are obtained by admitting the water to large open reservoirs where, in contact with the atmosphere, the CO_2 escapes and the calcium and iron salts precipitate. These salts color the water yellowish brown.

The second type, containing a little more CO_2, is the *thermal sprudel baths*, and is obtained by conducting water to subterranean air-tight tanks, from which it is conveyed to bathing tubs. This water is clear or slightly yellow, owing to its having lost but a proportion of its CO_2.

The third grade, or effervescent type, is known as the *sprudel baths*. They contain the full amount of CO_2. In their nascent state the waters contain from 550 to 1300 c.c. of CO_2 to the liter, but, of course, much of this instantly escapes as soon as the water reaches the tub. These baths are strongly effervescing, bright, sparkling, and clear as crystal.

Clear brine baths, containing 3 per cent. of chlorids and no gas, are also used.

Artificial Nauheim baths are quite extensively used, and some advantages are claimed for them by those who have taken the trouble to apply them in selected cases according to a definite scheme of gradation. Dr. Thomas E. Satterthwaite and Dr. C. N. B. Camac, of New York,* Dr. J. M. Anders, Dr. S. Solis Cohen, and Dr. James Tyson, of Philadelphia, have endeavored to place this form of treatment on a definite and effective basis.† The necessary salts can be obtained in the most convenient form from several manufacturers, and the use of cakes of acid sodium sulphate, as furnished by them, is far preferable to the hydrochloric acid which was previously used for the acid element in the bath. The latter is liable to destroy the tubs and injure the patient.‡ If the prepared salts are not accessible, the elements may be prepared as follows: Take sodium carbonate, 1½ pounds; sodium bicarbonate, ½ pound; calcium chlorid, 3 pounds; sodium chlorid, 2 pounds. Mix and dissolve in the bath and add slowly the sodium bisulphate, 1 pound, which should be kept by itself. This gives a bath of moderate strength. The box of Cassebeer Nauheim Salts contains eight discs of acid sodic sulphate wrapped in heavy lead-foil, and four packages, one pound each, of sodium bicarbonate. The method of preparing the bath is as follows: Fill a porcelain or enamel tub with 50 gallons of water at 105° F. (40.5° C.). The required amount of bathing salt is then added. This, in an ordinary Nauheim bath, should consist of from 2 to 3.5 per cent. of a mixture of sodium chlorid and calcium chlorid. In the stronger baths the imported concentrated salts, the Mütterlauge of Nauheim, is added to this mixture. It contains about 75 per cent. of calcium

* International Clinics, vol. i, thirteenth series, 1903.

† Trans. Philadelphia County Medical Society, January 31, 1905.

‡ Standard packages containing cakes of acid sodic sulphate and packages of sodium bicarbonate are supplied by the Shepard Pharmacal Co., 275 Water Street, New York, and The Triton Salt Co., New York City.

chlorid, and may be added to the bath at about the middle of the course.

The German package, known as Dr. Zucker's Carbonated Bath, contains a pint of formic acid solution instead of the cakes of acid sodic sulphate, and is in every way preferable. It can be obtained from George B. Evans, 1106 Chestnut street, Philadelphia. It is made by Max Elb, of Dresden.

Dr. Satterthwaite has formulated an excellent scheme for the six weeks' course of 35 graduated baths, which will prove useful in practice.

First week (No. 1 Bath).—0.5 per cent. plain warm salt bath. (Two pounds of bathing salt to 50 gallons of warm water.) Temperature, 98° F. (36.7° C.). Duration, four minutes. Intermission on the third and sixth days of this week.

Second week (No. 2 Bath).—0.75 per cent. warm salt bath. (Three pounds of bathing salt to 50 gallons.) 0.25 per cent. carbonic acid gas (two discs acid sodic sulphate to one package, one pound, sodium bicarbonate). Temperature, 97° F. (36° C.). Duration, six minutes. Intermission on the fourth day of this week.

Third week (No. 3 Bath).—One per cent. warm salt bath. (Four pounds of bathing salt to 50 gallons.) Temperature, 96° F. (35.5° C.). Carbonic acid gas, 0.5 per cent. (Four discs to two packages.) Duration, eight minutes. Intermission on the fourth day.

Fourth week (No. 4 Bath).—1.25 per cent. warm salt bath. (Five pounds bathing salt to 50 gallons.) Nauheim concentrated brine salts. Mütterlauge salts, eight ounces, or a half pint of the liquid salts, CO_2, 0.75 per cent. (Six discs to three packages.) Temperature, 95° F. (35° C.). Duration, ten minutes. Intermission on the fourth day.

Fifth week (No. 5 Bath).—1.5 per cent. warm salt bath. (Seven pounds bathing salt to 50 gallons.) Mütterlauge salts, three-quarters pint, CO_2, 0.75 per cent. (Six discs to three packages.) Temperature, 94° F. (34.4° C.). Duration, twelve minutes. Intermission on the fifth day.

Sixth week (No. 6 Bath).—Two per cent. warm salt bath. (Ten pounds of bathing salt to 50 gallons.) Mütterlauge, one pint, CO_2, 1 per cent. (Eight discs to four packages.) Temperature, 93° F. (34° C.). Duration, fourteen minutes. Intermission on the fifth day.

In the case of robust people we may commence with No. 2 bath, or in the case of delicate persons it may be best not to exceed the strength of No. 4 bath.

In preparing the bath the best way is to draw about 20 gallons of hot water in the tub. A tub 5 feet long will then be filled to a depth of 6 inches. The sodium chlorid is then dissolved and well distributed, and if the Mütterlauge is to be used, it is thoroughly diffused through the bath. The cakes of acid sulphate are now broken with a hammer, and laid on the accompanying lead-foil, and the bicarbonate is laid on top, two discs to one package. The water is now drawn in the

bath so that the 50 gallons shall have a temperature as designated, 98° F. (36.7° C.) for No. 1 bath, or 93° F. (34° C.) for No. 6 bath. The alkaline and acid salts are then lowered on their leaden foils at places along the bottom of the tub. Effervescence begins at once, and may take eight or ten minutes for completion. It is best to start with water a little above the required temperature, to allow for cooling; the lead and any undissolved sulphate should be removed before the patient enters.

Massage may be employed in the bath, after which the patient is carefully dried with warm towels and put to bed; or, at least, the patient should rest for an hour.

The effect of the baths at Nauheim, and of the artificial bath, is principally on the heart and blood-vessels. The resistance movements which have been systematized by Professor Theodore Schott and his brother, the late Dr. August Schott, are an essential feature of the treatment, and are most thoroughly carried out at Nauheim, and are supplemented by the "Terrain Kur," or graduated walks on the hill-side (Oertel system).

The immediate effect of the first bath is a diminished pulse-rate, intensified heart-sounds, and, in a case of extreme cardiac dilatation, a reduction of the size of the heart and of its cavities. This has been noted by competent observers after a single bath. While the latter is not always maintained, each succeeding bath leaves the organ a little smaller than in the previous one, and thus compensation is finally restored, in most cases, at least.

An important point in the selection of cases suitable for Nauheim treatment is that cases in which the neurosal element predominates are more likely to derive benefit than those presenting manifest organic heart changes. Cases of the latter type ought not to be encouraged to go to Nauheim, in the opinion of many competent observers.* In many of these cases positive harm results, and the more energetic and prolonged the treatment, the greater the harm. The question arises whether many of the cases reported by Bezly Thorne and other warm advocates of Nauheim treatment are not merely cases of cardiac dilatation, and perhaps hypertrophy, largely due to functional disability of cardiac ganglia and nerves; the cardiac bruits, more or less intense and prolonged, usually soft in character, may be wholly of nervous origin, as Robinson points out, and quite independent of recognizable blood changes, or changes in the locality and size of the heart.

OXYGEN BATHS

These baths act in very much the same manner as carbon dioxid baths, and are used in similar cases. They have been introduced from Germany, where they originated in 1904, and are known as Perogen baths, Ozet baths, Zeozon, Brozon baths, etc., according to the particular brand. They depend on the use of about 300 gm. of

* Beverley Robinson, Trans. Assoc. Amer. Phys., 1905, p. 44.

sodium perborate, and then adding 15 gm. of manganese borate. The agents for the Perogen bath in the United States are Morgenstern & Co., of New York. Each package is capable of generating about 35 pints of nascent oxygen. The patient lies in a tub full of water between 90° and 98° F. (32°–36.6° C.), and no friction or other movements are used. No other chemicals are, as a rule, employed, although, as in Nauheim baths, sodium chlorid or calcium chlorid might be added to the bath.*

MUD-BATHS. FANGO PACKS. PEAT BATHS

These are applied for rheumatism, gout, arthritis deformans, and neuralgias.

They act principally through the heat applied, and are, of course, not dependent on absorption of the mineral contained in the bath. No doubt the skin is favorably affected by the saline and alkaline substances employed. The patient lies in a tub containing the prepared mud mixed with the saline or carbonated water.

The most famous mud-baths are those of Carlsbad, Kissingen, Baden-Baden, Leipsic, Vienna, Wiesbaden, Franzensbad, and Battaglia, Acqui, and Salsomaggiore, Italy.

Fango is an Italian volcanic mud; it is a soft, gray-brown, plastic substance, of about the consistency of butter, and equally soft to the touch. It has no odor, and after application is quickly and completely removed by a warm douche, leaving the skin absolutely clean. The analysis shows that it is composed of 11 per cent. of combustible and volatile matter, with carbonates and sulphates and sulphids of iron and lime and sulphates of potassium and sodium. It is said to be radioactive. The fango is applied warm, like a great sterilized poultice. It conveys heat and retains it. The packs, or fanghi, may be applied first at 110° F. (43° C.) for ten minutes, the temperature and duration increased in successive applications up to 125° F. (52° C.) for twenty, thirty, and forty minutes. Massage may be applied gently after the pack.

The fanghi of Salsomaggiore consist of dried potters' clay saturated with the natural saline mineral water, and mixed with a considerable quantity of the raw petroleum at one establishment, known as the "Terme Magnaghi," and with the *acqua madre*, or heavy calcium chlorid water, at another establishment. The *fanghi* are kept on for about twenty minutes, are then scraped off, and the patient goes to the mineral-water bath.

Applied in this manner to a joint or a limb, the effects are: Stimulation of cutaneous reflexes, with dilatation of superficial capillaries; increased activity in the normal processes of absorption of morbid deposits and repair of damaged tissues. Perspiration is promoted, and there is a slight increase of body temperature, 2° F. (—16.7° C.),

* For a full description of this bath see author's Hydrotherapy, W. B. Saunders Co., 1910, pp. 323–332.

subsiding rapidly after removal of the pack, and due to direct conveyance of heat to the blood.*

Dr. Cecil Sharpe, of London, has recently reported 13 cases of stiff and painful joints treated in this manner. In subacute rheumatism, lumbago, rheumatoid arthritis, neuritis, sciatica, sprains, and old injuries of the ankles, fango gives good results. Among its advantages is the application only to the part involved, and the fact that these packs are given in various cities with the mud imported from Battaglia, where the fango is found in connection with hot springs. This treatment can be obtained in Battaglia, at the Anstalt for physiologic therapeutics, University Clinic, Munich, at London, and at Smedley's, Matlock, England, and at The Fango Institute, 69 West 90th Street, New York city.

Peat baths are used in chronic pelvic affections. Their action is like that of a wide-spread poultice. They are useful in gout, rheumatism, lumbago, and sciatica.

SITZ-BATH; HIP-BATH

A special tub is required for hip-baths, so that the patient may sit in water with his thighs resting against the front of the tub, and his knees, legs, and feet protected by a blanket untouched by the water.

Fig. 188.—Sitz-tub.

The top of the patient's head is covered with a cold wet cloth, and the tub is partly filled with water, so that as he sits down the tub is nearly filled. In this way one is sure that the temperature of the water is right to start with, and it can be raised or lowered afterward if required. If necessary to raise the temperature above 104° F. (40° C.), pitchers of hot water can be added cautiously, or, on the other hand,

* W. Cecil Sharpe, M.D., Journal of Balneology and Climatology, January, 1905.

if necessary to lower the temperature, cold water can be added. In the latter case quick friction of the submerged portions is required. The hot bath raises the pulse and lowers the pressure, the reverse being the case when cold water is used. The results are largely due to reflux excitation of the sympathetic nervous system. The hot bath diverts blood from the abdominal organs, while cold baths congest them. Hence, in all atonic states of the bowels and urinary and generative organs, cold acts as a stimulant if the baths are short and friction is applied. If such baths are prolonged, the stimulant effect is not obtained. It should be remembered in giving the sitz-bath to carefully cover the unimmersed parts of the body, otherwise, the effect may be entirely annuled, especially in intestinal affections.

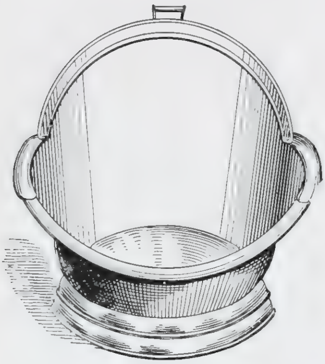


Fig. 189.—Sitz-bath tub made of tin.

In menstrual disorders warm and hot sitz-baths are often corrective.*

Brief cold hip-baths are useful in vesical and intestinal paralysis, and in debilitative states of the male sexual organs, in prolapsus, and in intestinal atony. They are counterindicated in hyperemic states of congestions of the pelvic organs; in sexual or vesical irritability; seminal emissions, tenesmus, and menorrhagia.

Prolonged cold hip-baths are advocated by Misiewitz in hemorrhagic states of the urethra, bladder, intestines, and uterus; in hemorrhoids and perimetritis. They are unsuitable in uterine colic, acute cystitis, and intense tenesmus.

HOT MOIST PACK

The hot moist pack is useful in uremia. Many a case of puerperal convulsions has been saved by this procedure. It is commonly used after the warm douche and warm or hot baths in the treatment of gout, rheumatism, syphilis, and obesity.

Place a mackintosh and blanket under the patient. Wring a blanket out of as hot water as the patient can bear without burning, and wrap very quickly, covering all with a mackintosh. Hot-water bags properly covered should be placed along the limbs and at the feet, and an ice-cap to the head. The duration of the pack should be specified. Pulse and respiration should be carefully watched. The patient should perspire in ten, fifteen, or twenty minutes.

* For a full discussion of hydrotherapy in diseases of women see Ashton's Practice of Gynecology, W. B. Saunders Company, fourth edition, and Bandler's Medical Gynecology, W. B. Saunders Co., second edition.

COMPRESSES

The materials used are linen for the cold wet compress, which is then covered closely by several thicknesses of flannel to prevent outward radiation. For the moist hot compresses well-soaked flannel is used, covered, as in the former case, with a sufficient layer of dry flannel. The good effects of a cold compress are well seen in the treatment of pneumonia. The water should be at 55° or 60° F. (13°–15.6° C.). The linen compress, 18 inches wide, partly wrung out, is laid smoothly over the affected side, extending slightly beyond the median line front and back, and is then covered with a flannel

Fig. 190.—Method of wringing out a hot compress without scalding the hands (Ashton).

binder, not too snugly applied. This should be changed night and day every hour, and it is possible to do this without much disturbance of the patient. The danger in these cases is from the intoxication; as a general thing, the intoxication is not so great in pneumonia as in typhoid, and full baths are not desirable. There is a failure in peripheral circulation, and this causes hypertension of the heart, the blood being driven to the inner parts. Just here is where the compress gives timely assistance. The cold stimulates the heart, and with the systole blood is driven into the peripheral vessels. The central nervous system is also invigorated by the effect of cold on the arterioles. As the skin reacts and the peripheral circulation improves, the heart

beats slower and stronger and the increased force and tension of the pulse are shown in the kidney, and we get more urine. The pulse is improved in rate and in character. The crisis is hastened and is marked by a drop in the temperature and a notable reduction in the rate of the pulse. In cases of collapse with cardiac weakness a cold compress should be placed around the trunk (Neptune's girdle), while the extremities of the limb should be heated.

The use of ice in pneumonia rests upon the same basis. The end sought is not the reduction of temperature, but a check to the intoxication by improved circulation and consequent nutrition. It is possible that by these means antitoxins are developed to counteract the infection. The crisis in pneumonia is sudden and not fully to be explained. The remarkable effects cannot be accounted for by immediate changes in the physical condition of the lung. If so, hydrotherapy would be powerless; it is, therefore, a mistake to expect the compress to cure the condition of the lung itself. If the patient recover, he recovers in spite of the pulmonary consolidation; if he die, it is not altogether from the encroachment on his breathing capacities, but from the intoxication. Put two intoxications together, as that of alcohol and pneumonia, and the result is usually fatal. As a rule, it is not best to give alcohol in cases of pneumonia treated with compresses, but in alcoholic cases some may properly be given; but it requires nice judgment to decide when to give and when to withhold. As in any other form of treatment, little can be expected from these measures in alcoholic cases, especially if treatment is started late, as, for instance, on the third day.

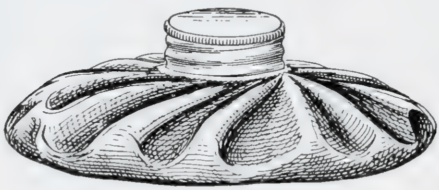


Fig. 191.—Ice-bag.

Ice Compresses.—The application of ice to the body is best made by means of water-tight rubber ice-bags. It is obviously best to prevent wetting the bed and the patient's clothing. As stated above, we do not aim to reduce inflammation, as in pneumonia, for the lungs of a living man would not be appreciably affected by cold applied outside the chest-wall.

Hot Compresses.—Dry heat may be applied to the body by means of hot flannel compresses. It is better not to interpose linen or cotton, but to have the flannel in direct contact with the skin. This induces hyperemia of the skin, and relieves internal congestion. The compress should be covered with several folds of flannel to prevent external radiation.

Moist heat is easily applied by steam compresses. They are called for in many surgical conditions; they favor suppuration, promote the absorption of exudates, relieve pain, and increase the mobility of stiffened joints. In all cases of rheumatoid arthritis; arthritis deformans with pain and swelling; in sprains, bruises, cramps of the

extremities; in biliary, renal and hepatic colic, moist or wet hot compresses are exceedingly useful. Fomentations are useful in sciatic neuritis, multiple neuritis, or any non-traumatic neuritis of an advanced stage.

The illustration (Fig. 190) shows a convenient method of preparing a steam compress. Several layers of flannel of a suitable size and fastened together are dipped into boiling hot water. The area to be treated is then covered with a thin layer of dry flannel—the so-called "baby" flannel answers the purpose best. The wet compress is now dropped into a towel, which is then twisted tightly so as to leave it comparatively dry. It is then unfolded, placed over the dry flannel referred to, and the whole enveloped in a dry flannel binder. Dry and moist compresses require frequent change to be effective, and if applied directly to the skin, should be tested by the physician or nurse before applying to the patient.

In explanation of the relief of pain by means of local heat it is

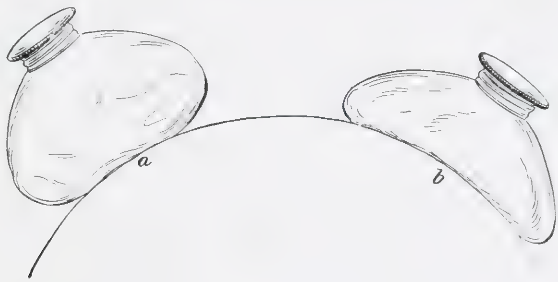


Fig. 192.—Incorrect (*a*) and correct method (*b*) of applying an ice-bag (Ashton). Note that in illustration *a* the bag is distended with air and does not adjust itself to the surface of the body. In illustration *b* the air has been expelled before screwing on the cap and the bag hugs the parts closely.

reasonable to suppose that when arterial and venous congestion occur in a given part there is a corresponding compression of the nerve-trunks by the overfilled blood-vessels. Spasm of the nutrient vessels, by which the nerve-filaments are compressed, has also been supposed to account for the pain. If the blood may be diverted to the surface or to some other part by the use of compresses, relief will be afforded.

In cases of traumatic neuritis a cold compress or an ice poultice, ice and bran mixed, may be placed over the nerve at the seat of injury, while the distal portion of the limb is wrapped in moist, warm flannels.

Cold applications are useful in conjunctivitis neonatorum. In the early stages, when the lids are tense and there is little secretion, small square compresses of patent lint (perfect absorbent lint) are laid on a block of ice and are frequently applied to the eyes to keep up a uniform cold impression. They are also useful in the first stage only of traumatic iritis and wounds of the eyeball.

Fomentations are used in conjunctivitis neonatorum, especially when corneal complications exist or the conjunctiva has a gray film. These are applied with squares of antiseptic gauze wrung out of carbolized water at 120° F. (49° C.), and should be frequently changed. These are used in connection with irrigation of the eyelids.

Fomentations are useful in cases of acute endocarditis having a weak heart and a feeble, irregular pulse. They should be employed locally over the heart, and are more stimulating than ice-bags or cold compresses.

Murphy's Method of Proctoclysis.—This and other methods of rectal and vaginal irrigation are described in the author's "Hydrotherapy," pp. 359–370.

BATHING ESTABLISHMENTS FOR THE PUBLIC

Public Shower Baths.—There are hundreds of these in the United States, and nearly all have been established since 1890. Floating baths had been established previously in New York, Brooklyn, and Boston, and Philadelphia and Chicago had pools; but all these were used only during the warmer portion of the year. It was owing to the active influence of Dr. Simon Baruch, of New York, who made the first plea for rain or shower baths in this country in 1889, that so much has been done to give to the poor practical bathing facilities. The Committee of the County Medical Society of New York recommended that public baths be located in the very center of the overcrowded district. The buildings should be modest in style, so as not to repel the poor; they should be so constructed that a cleansing bath may be obtained without trouble and expense, or at a trifling expense and without much loss of time. Following the German plan, warm rain or shower baths are substituted for the old-fashioned bath-tub. These are supplied with reservoirs of some height, affording considerable pressure. The outlay for tubs and their necessary care are avoided. The time for a shower bath is far less, and there is much greater economy of space and in the quantity of water needed. Only one-tenth the amount of water is required. There is no danger of communicating disease. The refreshing effect of the shower, whose temperature may be gradually reduced after cleansing, is valuable and prevents danger from the relaxing effects of the warm tub-bath.

At the Volksbad, in Vienna, 70 persons can be accommodated at once, and for five Kreutzer (2 cents) the bather receives a towel, an apron or mantle, a piece of soap, and a key to a closet, where he places his clothing. He turns the water on, soaps himself thoroughly, and again opens the valve of the shower, which descends with so much force that it aids the bather in the cleansing process. In five minutes he finds himself more clean than he would become in a longer period in a tub-bath, the water of which must become soiled before its termination. The water as it runs is quickly drained away. The apartment is soon ready for another occupant. It was pointed out

that a river bath in summer is not to be compared in efficacy with the warm shower bath in a well-lighted, well-ventilated, pleasantly warm room with facilities for drying and dressing.

The New York Association for Improving the Condition of the Poor established on these lines the "People's Bath" and other baths. The Floating Baths of New York, and the municipal pool baths of Philadelphia, furnish over 5,000,000 baths a year. In the slum district of our larger cities few houses have bathing facilities. In such districts in New York city 93.5 per cent. are without them; in Chicago, 96.2 per cent.; in Baltimore, 90.8 per cent.; and in Philadelphia, 82 per cent. The need of greater bathing facilities is very great. In visiting 480 houses in the selected district in New York, but 17 had bath-houses; and in 378 houses in Philadelphia, 67 had bath-houses.

The author visited, with Dr. Baruch, the Riverside Association Bath in West 65th Street, New York, and was most favorably impressed with the system of rain baths, hot-air baths, circular jet and Scotch douches as afforded at nominal cost for the poorer classes.

The Philadelphia Public Bath Association conducts three bath-houses, and furnished nearly 200,000 baths in 1909 at a cost of five cents to each bather. Pool baths are employed.

SEA-BATHS

The important features of the sea-bath are the temperature, ranging from 52° to 75° F. (11° to 24° C.); the force of the waves; the effect of the salt in solution (1.6 per cent.) on the skin, and the opportunity for exercise in the bath. These are elements of great power for good or evil, but very little consideration is given to them by the hundreds of thousands of bathers during the summer months. Winter sea-bathing is popular on the Florida coast, at Nassau, and at Coronado, California. The temperature of the water at Nassau and at Palm Beach averages 70° F. (21° C.) in January, February, and March, and 56° to 58° F. (13.3° C. to 14.4° C.) at Coronado. At San Francisco it is about 52° F. (11.1° C.) the year round. The Gulf Stream emerges from the Gulf of Mexico in a narrow channel between Florida and Cuba, and follows the coast until it is about 65 miles distant from shore at Atlantic City. Its center is 135 miles from Atlantic City, and about 185 miles distant from Sandy Hook. Its influence on the American coast is not felt very much beyond Cape Cod. At Virginia Beach bathing is good May 1st; on the New Jersey Coast as early as June 1st; on the New England coast, beyond Boston, by the end of June. On the coast of Maine, the temperature of the water varies from 55° to 67° F. (12.8° to 19.4° C.), and the season is from July 1st to September 10th. At Cape May, N. J., the temperature of the water rises from 65° F.

* In 1909 the total attendance at the public swimming pools of Philadelphia was 5,637,346.

(18.2° C.) June 1st to 75° F. (24° C.) in early September. On the Atlantic coast there are variations of temperature according to the wind: strong southerly winds raise the temperature, while "off shore" winds lower it.

At Atlantic City in August nearly 100,000 persons may enjoy sea-bathing in a single day. On Long Island Sound the temperatures are higher and the surf less than on the sea-coast proper. The advantages of these quieter waters for the young and delicate are obvious.

It is apparent that sea-bathing must be considered strictly in reference to local conditions before it is advised or condemned with regard to a particular case. It might agree with a person at Old Point Comfort or Cape May and be totally unsuitable on the coast of Maine. The daily variation in the force of the waves and the presence of unusual currents are important factors.

For the strong and healthy individual the sea-bath is usually exhilarating and refreshing. The best time for bathing is in the forenoon, before the midday meal, not at the end of an exhausting day of work; not before breakfast or at night; never directly after eating. These simple rules, however, are constantly violated by people who either cannot chose their bathing hour or, on the other hand, indulge in two or three baths in a day. The shorter the summer vacation, the greater is the temptation to overindulgence. In their eagerness to get the worth of their money these persons lounge about the beach in salt-soaked bathing suits, cover themselves with sand, go in again, and repeat the process, expecting to toughen themselves by the most unhygienic, foolhardy, and dangerous practices. The ordinary bath of ten or fifteen minutes is prolonged to hours.

The principal safeguard in bathing is a good and prompt reaction. There should be a good glow, and it should be maintained by active exercise in the water. The body should be completely immersed; wading in shallow water and failure to wet the head and chest produce irregular circulation. Reaction is delayed in the weak and in elderly people, whose skin circulation is languid and whose heart action is poor; in those who are fatigued or overheated before bathing, and who are not accustomed to the low temperature of the ordinary sea-bath. Those who are bathing for the first time in the season should be cautious and moderate until they are better accustomed to it, and inexperienced bathers had better avoid emulating the feats of the more venturesome. Muscular cramps are among the more formidable dangers to swimmers. They usually attack the leg muscles, and sometimes the trunk, and quickly render the swimmer helpless. They are generally due to overstrain, coming on without warning, during a long swim, and may occur in good swimmers. If the bather can be brought to shore, he should be rubbed vigorously, dried, and warmed.

Colicky pains and abdominal spasms may follow a sea-bath too soon after eating. Two hours after a meal is a safe rule, but three

hours is better if digestion is likely to be delayed. The effects of a sudden shock of cold water before digestion is accomplished are best met with heat externally, dry rubbing, and a small amount of tincture of ginger and water or a little whisky.

THE HYDROTHERAPEUTIC PRESCRIPTION

At the outset, it is best to be cautious, using only moderate measures. The brilliant results in hydrotherapy are not obtained by a few master strokes, by the employment of long baths, or rather high or low temperatures at the beginning. Caution is especially necessary in all doubtful cases. It is much easier, and time is usually saved, by leading the patient on from the milder procedures to those more complicated. His confidence is established; his resistance or endurance is educated, and in the intelligent gradation of the baths lies the secret of success.

While it is not a very good plan to prescribe from a book for a given disease, nevertheless in hydrotherapy there are certain well-established procedures, more or less identified with bodily conditions, which it would be proper to commend. These have been gathered from various quarters, and have been gradually evolved or differentiated from fundamental principles of hydrotherapy. The prescriptions are employed by Baruch, Beissel, Beni Barde, Boas, Dehio, Erb, Fodor, Hegglin, Hoffman, v. Jaksch, Derecq, Kellogg, Laqueur, Matthes, the late Professor Nothnagel, Joseph H. Pratt, Romberg, Senator, v. Strümpell, Schweinburg, Stintzing, and last, but not least, Winternitz, from whom all the others have learned their hydrotherapy. The arrangement in the main is that adopted at the Medical Baths in Boston, under the direction of Dr. J. H. Pratt, to whom the author is indebted

PRESCRIPTIONS

ABBREVIATIONS

H. A. B.	Hot-air bath
Pn.	Perspiration
C. D.	Circular douche
J. D.	Jet douche
S. D.	Scotch douche
F. D.	Fan douche
P.	Pressure

(1) Hot pack until the skin is warm and the cutaneous vessels dilated. Wet-mit friction, using water at 60° F. (15.6° C.). Repeat daily, reducing temperature of water 2° F. (1° C.) at each treatment until 50° F. (10° C.) is reached.

(2) Hot pack until skin is warm. Cold wet towel rub; temperature of water, 60° F. (15.6° C.). Repeat daily, lowering temperature of water 1° until 50° F. (10° C.) is reached.

(3) Hot-air bath, nearly to point of perspiration. Wet sheet

rub; temperature of water, 70° F. (21.1° C.). Repeat daily, lowering temperature 1° each day until 60° F. (15.6° C.) is reached.

(4) Hot-air bath to perspiration. Half bath; water at 70° F. (21.1° C.); duration, one minute. Repeat daily, lowering temperature gradually to 60° F. (15.6° C.), and increasing length of bath to three minutes.

(5) Hot-air bath to perspiration. Circular douche, 105° F. (40.5° C.), gradually lowered to 90° F. (32.2° C.) during two minutes. Jet douche succeeded by fan douche to entire body from neck down, 90° F. (32.2° C.), reduced to 80° F. (26.7° C.). Pressure, 10 pounds, one minute. Lower minimum temperature 2° F. and increase pressure 2 pounds at each treatment until a temperature of 60° F. (15.6° C.) and a pressure of 30 pounds are used.

(6) Carbon dioxid bath. For this use the Cassebeer salts furnished by the Shepard Pharmacal Co., New York, or the Triton Salts, or to 40 gallons of water add 300 gm. Na_2CO_3 and 300 c.c. HCl. Duration, eight to ten minutes. The salt and acid may be increased to 500 gm. of each, and the duration to fifteen minutes. For technic and cautions see p. 480.

(7) Hot-air bath to perspiration. Circular douche, 95° F. (35° C.), reduced to 80° F. (26.7° C.), thirty seconds. Spray douche, 70° F. (21.1° C.), 30 pounds, five seconds. General massage, ten minutes. Reduce temperature of spray douche 1° F. daily.

(8) Vapor bath; temperature, 120° F. (49° C.), one-half hour. Friction with warm dry towels. Rest in bed one hour.

(9) Hot-air or vapor bath, fifteen to twenty-five minutes, followed by dry pack thirty minutes. Rest in bed one hour.

(10) Electric, hot-air, or vapor bath, fifteen to twenty-five minutes. Circular douche, 105°, reduced to 90° F. (40.5° to 32.2° C.), two minutes. Jet and fan douche, 90°, reduced to 85° F. (32.2° to 29.5° C.), one minute; pressure, 10 pounds. Repeat two or three times weekly, increasing pressure 2 pounds and reducing final temperature 2° each treatment until 30 pounds and 60° F. (15.6° C.) are reached.

(11) Local hot-air or electric-light bath to affected joint; temperature, 190° to 195° F. (87.8° to 90.5° C.), one hour. Spray douche, 70° F. (21.1° C.), 15 pounds pressure, ten seconds. Repeat daily until the hot-air bath reaches 265° F. (130° C.), increasing by 2° or 3° F. each day.

(12) Local electric-light bath, fifteen minutes. Spray douche, 70° F. (21.1° C.), 15 pounds pressure. Repeat daily, increasing duration of light bath by two minutes to a maximum of forty minutes. J. D., 16 pounds; 104° F. (40° C.); six, eight, or ten minutes.

(13) Full bath; 104° F. (40° C.), eight to ten minutes. Hot pack three or four blankets, ten minutes. Cool douche to spine and trunk, five to ten seconds, 65° to 70° F. (18.3° to 21.1° C.). Dry body and rub with alcohol, using 2 ounces of alcohol.

(14) General hot-air bath to point of perspiration. Circular douche, 105° F. (40.5° C.), increasing to 110° F. (43.3° C.), and reducing to 90° F. (32.2° C.) in two minutes; pressure, 20 pounds. Scotch douche to affected part or painful areas; 110° and 90° F. (43.3° and 32.2° C.); pressure, 10 pounds. Repeat daily, increasing pressure of C. D. 1° until 30 pounds is reached, and S. D. 1 pound until 20 pounds is reached.

(15) Massage and douche, "Aix douche," to the affected joints; temperature of douche, 92° to 100° F. (33.3° to 37.8° C.). Duration, ten minutes. Circular douche, 98°, increased to 110° F. (36.7° to 43.3° C.), two minutes. F. D. and J. D. to entire body. Temperature, 70° F. (21.1° C.); pressure, 15 pounds, ten minutes.

(16) Vapor bath, 120° F. (49° C.), ten minutes. Scotch douche, 110° and 90° F. (43.3° and 32.2° C.). Hot pack, thirty minutes. Rest in bed one hour. Repeat three times a week.

(17) H.A.B. to Pn., C. D., 105° to 90° F. (40.5° to 32.2° C.), two minutes. Rain douche, 86° reduced to 80° F. (30° to 26.7° C.), forty seconds. Pressure, 10 pounds. Oil rub. Reduce final temperature of R. D. 1° and increase pressure 1 pound until temperature of 60° F. (15.6° C.) and pressure of 20 pounds are reached.

(18) Full bath, 100° to 102° to 104° F. (37.8° to 39° to 40° C.) in three successive days, ten minutes. Massage in the tub. Hot pack with dry sheet and three or four blankets, ten minutes. Cool sponging with water at 70° F. (21.1° C.) or J. D. at 10 pounds, ten seconds. Dry and rub with alcohol, using 2 ounces; omit every fourth day.

(19) H. A. B. to Pn. C. D., 110°, reduced to 100° F. (43.3° to 37.8° C.), two minutes. J. D. to entire body; pressure, 15 pounds; 70° F. (21° C.), twenty seconds. Repeat daily, raising pressure 2 pounds and reducing temperature of J. D. 2° each treatment until 30 pounds and 60° F. (15.6° C.) are reached.

(20) H. A. B. to Pn. C. D., 105°, reduced to 95° F. (40.5° to 35° C.), two minutes. J. D. to abdomen, 75° F. (24° C.), thirty seconds, 10 pounds; spray douche to entire body, 75° F. (24° C.), ten seconds; pressure, 12 pounds. Abdominal massage. Repeat daily, increasing pressure 1 pound and lowering temperature 1° until 25 pounds and 60° F. (15.6° C.) are reached. For enteroptosis.

(21) H. A. B. to Pn. C. D., 105°, reduced to 95° F. (40.5° to 35° C.), one minute. J. D. to abdomen, 10 pounds; 86° F. (30° C.), raised gradually to 120° F. (49° C.), fifteen to ten minutes. F. D. to abdomen, then to dorsal region, 13 pounds; 60° F. (15.6° C.), fifteen seconds. General J. D. at 13 pounds; 60° F. (15.6° C.), fifteen seconds. Repeat daily for gastralgia.

(22) H. A. B. almost to Pn. C. D., 105°, reduced to 95° F. (40.5° to 35° C.), one minute. Small J. D. to course of the colon; alternate, 60° and 115° F. (15.6° and 46° C.), fifteen seconds each; pressure, 15 pounds, one to two minutes. F. D. to chest and back, 75° F. (24° C.), 15 pounds, ten seconds. Repeat daily for constipation,

increasing pressure 2 pounds each treatment until 30 pounds are used.

(23) H. A. B. until cutaneous vessels are dilated. Wet sheet rub; temperature, 70° F. (21° C.). Sitz-bath, temperature, 70° F. (21° C.), ten minutes. Simultaneous hot foot-bath; temperature, 110° F. (43.3° C.). Repeat daily, increasing duration gradually to twenty minutes and lowering temperature to 50° F. (10° C.). For diarrhea of relaxation.

(24) H. A. B. to Pn. C. D., 105°, reduced to 95° F. (40.5° to 35° C.), one minute. Perineal or ascending douche, 60°, increased to 70° F. (15.6° to 21° C.), two to three minutes; 5 to 10 pounds pressure. Rain douche, 105° F. (40.5° C.), thirty seconds. F. D. to body, ten seconds, 15 pounds; 70° F. (21° C.). For hemorrhoids and hypertrophy of prostate.

(25) H. A. B. to Pn. C. D., 105°, reduced to 90° F. (40.5° to 32° C.), two minutes. J. D. and F. D., 90° reduced to 80° F. (32° to 26.7° C.), fifteen pounds; one minute. J. D. to spine, 75° F. (24° C.), fifteen seconds; lower minimum temperature, 2° F., and increase pressure 1 pound each application until pressure of 35 pounds and temperature of 50° F. (10° C.) are reached.

(26) H. A. B. until cutaneous vessels are dilated. Remove before perspiration begins. C. D., 20 pounds; 95°, reduced to 85° F. (35° to 29.5° C.), one-half to one minute. General F. D., 80° F. (26.7° C.), 20 pounds, ten to twenty seconds. Dry rapidly. Walk in open air until somewhat fatigued. Repeat daily, reducing minimum temperature 1° each treatment. Once during the week allow the patient to perspire five minutes in the cabinet.

(27) H. A. B. almost to point of Pn. C. D., 20 pounds; 95°, reduced to 85° F. (35° to 29.5° C.), one-half to one minute. F. D. to back, 75° F. (24° C.), 20 pounds, five seconds. General F. D., 78° F. (25° C.), 30 pounds, fifteen seconds. After several days, substitute J. D. for F. D. to back; lower temperature of general F. D. 1° daily.

(28) H. A. B. to beginning Pn. C. D., 25 pounds; 95°, reduced to 80° F. (35° to 26.7° C.), one minute. J. D. to back, 30 pounds; 5° F. (24° C.), five seconds. Reduce daily 1°; friction walk in open air.

(29) H. A. B. to Pn. C. D., 10 pounds; 105°, reduced to 92° F. (40.5° to 33.3° C.), three minutes. General F. D., 10 pounds; 85° F. (28.4° C.), fifteen seconds. Walk slowly in open air. Repeat daily, increasing pressure and lowering temperature until 15 pounds and 80° F. (26.7° C.) are reached. For neurasthenia.

(30) H. A. B. to Pn. Change cold compresses to head frequently. C. D., 100°, reduced to 90° F. (38° to 32° C.), 20 pounds, two minutes. S. D. to legs and feet 15 pounds; 100° and 80° F. (28° and 26.7° C.); thirty seconds. Repeat daily, increasing pressure 1 pound until 30 pounds pressure is borne. For persistent headache.

(31) Wet pack with water at 60° to 70° F. (15.6° to 21° C.), one hour. C. D. 85° F., 20 pounds, fifteen seconds. Repeat daily: once

or twice weekly make the initial temperature of C. D. 90° F. (32° C.), and reduce quickly to 75° F. (24° C.); follow with F. D. 85°, reduced to 65° F. (29.5° to 18.3° C.), 20 pounds, five seconds. For excitable hysteria.

(32) H. A. B. to Pn. C. D., 25 pounds; 85° F. (29.5° C.), thirty seconds. Spray douche, 65° F. (18.3° C.), 25 pounds, five seconds. After a few applications use J. D. to spine at end of treatment for three seconds; temperature, 65° F. (18.3° C.). Lower J. D. 2° daily until 50° F. (10° C.) is reached. If this is well borne, pressure may be increased 2 pounds daily until 30 pounds pressure is reached.

(33) Vapor bath, 120° F. (49° C.), fifteen minutes. Ice-bag to precordia. Salt glow. J. D. to entire body; 10 pounds; 110° F. (43° C.), thirty seconds. Rub dry. Rest in bed one to two hours. Repeat two to four times weekly, increasing pressure until 30 pounds are employed, and gradually increasing length of vapor bath to thirty minutes.

(34) Hot full bath, 100° F. (38° C.), raised to 106° F. (41° C.), five to ten minutes. Salt glow. F. D. or J. D. to body, 110° F. (43° C.), thirty seconds. Massage to edematous portions. Rest one to two hours before dressing. Repeat 2 to 4 times weekly, increasing pressure until 30 pounds are used. For chronic nephritis.

(35) H. A. B., forty to sixty minutes. Soap shampoo. Half-bath; temperature, 70° F. (21° C.), three to five minutes. General J. D. Pressure, 25 pounds; temperature, 70° F. (21° C.), twenty seconds. Dress quickly and walk until fatigued. Repeat daily, increasing duration of H. A. B. and lowering temperature of douche as condition of patient indicates. For obesity.

Prescriptions in use at the Medical Baths, Boston:

Prescription A.—Light cabinet, five to seven minutes.
Cold wet-mit friction to entire body.
Temperature of water, 70° F. (21.1° C.).
Repeat daily, gradually reducing temperature of water to 60° F. (15.5° C.) or lower.

Prescription B.—Light bath, five to ten minutes.
Circular douche, 105° F. (40.5° C.), thirty seconds.
Circular douche, 90° F. (32.2° C.), thirty seconds.
Jet and fan douche to entire body at 70° F. (21.1° C.), twenty seconds, pressure, 10 pounds.
Repeat daily, gradually increasing pressure of jet douche and lowering terminal temperature until pressure of 20 pounds and temperature of 60° F. (15.5° C.) are used.

It is written in an abbreviated form as follows:

L. B., five to ten minutes.
C. D., 105° F. (40.5° C.), thirty seconds.
C. D., 90° F. (32.2° C.), thirty seconds.
J. and F. D., 70° F. (21.1° C.), twenty seconds.
P., 10 pounds.
Repeat daily, increasing P. to 20 pounds and reducing T. to 60° F. (15.5° C.).

Prescription C.—Light bath, fifteen to twenty seconds.
Fan douche, 105° F. (40.5° C.), thirty seconds.
Fan douche, 70° F. (21.1° C.), fifteen seconds.
Dry rub.
Rest one hour.
Repeat every other day.

If the individual is weak, a milder procedure should be used (Prescription A)

Prescription D.—Light bath, seven to twelve minutes.
Salt rub.
Circular douche, 105° F. (40.5° C.), thirty seconds.
Jet and fan douche, 105° F. (40.5° C.), thirty seconds, pressure, 15 pounds.
Dry rub.
Rest thirty minutes.
Repeat three times weekly.

Useful in chronic interstitial nephritis.

In cases of chronic uremia, headache, loss of appetite, and vomiting it is well to use a wet-pack (one hour or longer) preceded by a light bath of three to five minutes' duration.

Prescription E.—Local hot-air or electric-light bath to affected joint, thirty minutes to one hour.
Electric-light bath, general, three to five minutes.
Jet douche to affected joint, 105° F. (40.5° C.), twenty seconds.
Jet douche to affected joint, 105° F. (40.5° C.), twenty seconds; 70° F. (21.1° C.), five seconds.
Repeat four times.
Circular douche to entire body, 105° F. (40.5° C.), thirty seconds.
Jet and fan douche to entire body, 70° F. (21.1° C.), ten seconds.
All douches at from 10 to 20 pounds' pressure.
Repeat three to six times weekly, increasing pressure gradually.

Prescription F.—Arc light, seven to ten minutes.
Light bath, five to ten minutes.
Alternate douche to affected part.
Circular douche, 105° F. (40.5° C.), thirty seconds.
Jet and fan douche, 70° F. (21.1° C.), ten seconds, pressure, 10 pounds.
Repeat daily, increasing pressure gradually.

Used in lumbago and sciatica.

Prescription G.—Hot-air douche to painful area, fifteen to twenty minutes.
Light bath, five to ten minutes.
Circular douche, 105° F. (40.5° C.), thirty seconds, pressure, 10 pounds.
Jet and fan douche to entire body, 70° F. (21.1° C.), twenty seconds, pressure, 10 pounds.
Repeat daily. Increase pressure of jet and fan douche and lower terminal temperature until pressure of 25 pounds and 60° F. (15.5° C.) are reached.

Nauheim Baths.—At the beginning of treatments the following general prescription may be given:

Prescription H.—Carbon dioxid bath, $\frac{3}{10}$ strength.
Temperature, 93° F. (33.8° C.).
Duration, seven minutes.
Increase strength one-tenth each treatment, lower temperature, 1 degree, and increase duration one minute.

Prescription I.—Carbon dioxid bath, $\frac{3}{10}$ strength.
Temperature, 93° F. (33.8° C.).
Duration, ten minutes.
Increase strength of bath gradually, lower temperature, and increase duration until a bath of eight-tenths full strength, 87° F. (30.5° C.), and twenty minutes is given.

Dr. Pratt finds that a powerful arc light is of service in the treatment of neuritis, myalgia, "rheumatic" joints, and neuralgia, particularly sciatica.

Special Hydrotherapy

TYPHOID FEVER

As early as 1802 Dimsdale published in London "An Account of Cases of Typhus Fever in which the Affusion of Cold Water has been Applied in the London House of Recovery." Since that time typhus and typhoid have been differentiated, and it remained for Brand, under the title "Die Hydrotherapie des Typhus," published in 1861, to rediscover this invaluable method of treatment. There are various modifications of Brand's method.

The Method of Brand in the Treatment of Typhoid Fever

"If the diagnosis of typhoid fever is probable, recourse should be had to the baths whatever may be the symptoms. The full tub should be placed in the ward or chamber, parallel to the bed, at a distance of one or two meters, the floors properly protected by oil-cloth, and a screen placed between the bed and the bath-tub. A sufficient quantity of water should be used to cover the patient's body to the neck. It should be of a temperature of from 64.4° to 68° F. (18° to 20° C.). The baths should be prepared without disturbance or noise. There should be placed on the floor near the head of the tub two pitchers of cold water of a temperature of from 46.4° to 50° F. (8° to 10° C.), each containing four or five quarts (liters). A glass of water should be at hand. The first bath should be given preferably about 4 o'clock in the afternoon, unless there is some urgent reason for selecting a different hour, and the physician should be present. The rectal temperature is taken, the urine is voided, and the patient is assisted into the full tub, the screen having been removed. If there is perspiration, the patient is dried before entering the bath. Cold water from the pitchers is poured upon the head and the back of the neck for one or two minutes, the amount being from two to three quarts (liters). Then a swallow of cold water or red wine is given. This being done, the whole surface of the body is briskly rubbed with a sponge or brush, and the patient is made to rub his abdomen and chest. These frictions stimulate the peripheral circulation, prevent the accumulation of heat at any one point, moderate the sensation of cold, and help to pass the time; they are not indispensable. Shivering appears, as a general rule, in between eight and twelve minutes; this is a necessary evil to which too much attention is not to be paid. Toward the middle of the bath, or at its termination, cold water is again poured over the head and neck. The time occupied ought to be at least fifteen minutes, longer if the head is still warm and the cheeks red, or if the temperature of the patient was very high before the bath.

"The patient should leave the bath without precipitation. He cannot take cold; thoracic complications are caused by typhoid

fever and not by chilling. The air of the apartment should be pure and not too warm; the window should be opened in the intervals between the baths; during the bath it ought to be closed. On leaving the bath, the patient should be gently dried with a towel. The bed should be carefully made during each bath. If on returning to the bed shivering takes place, the limbs should be rubbed and a hot bottle placed at the patient's feet. A cold compress, covered with oil-silk or flannel, should be placed over the abdomen, and a little warm nourishment administered. It is not necessary to renew the water of the bath every three hours; once in twenty-four hours is sufficient. As a rule, the patient should pass his water before entering the bath.

"Three-quarters of an hour after the bath the rectal temperature should again be taken. If, however, it is found to be below 101° F. (38.5° C.), it is not necessary to take it again for three hours.

"Alimentation should consist of the following articles: Milk diluted with coffee or tea or cocoa (a quarter of a liter at each administration); thoroughly cooked gruel, oatmeal, tapioca, or vermicelli; veal, mutton, or chicken broth, freed from fat when cold and reheated at the moment of administration. As a drink, pure cold water should be given; the indication for wine or spirits is urgent only in cases that are subjected to this treatment late in their course. If the patient does not sleep or sleeps badly, he is to have a draft of iced water, and the abdominal compress is to be changed every quarter of an hour. The discharges from the bowels are to be preserved for inspection, and the total quantity of urine may be collected in the same vessel. Neither age, sex, menstruation, pregnancy, nor sweating (except that which occurs at the end of defervescence) in any way modifies the treatment. In women who are weaning their children cold compresses should be applied to the breasts and frequently renewed. If diarrhea persists, it is to be combated by cold compresses, which may be kept cold by the aid of a bladder of ice. If there is constipation, it is to be treated by cold enemata, and if these fail, by enemata consisting of one part of cold water and one part of fresh ox-gall.

"When the temperature before the bath is very high, or if the fall forty-five minutes after the bath is less than 1.8° F. (1° C.), the bath must be prolonged to eighteen or twenty minutes. It is very rarely necessary to modify the general formula. After the temperature does not exceed 102.2° F. (39° C.), but yet reaches 101° F. (38.5° C.), it is necessary to treat these slight exacerbations by baths of 68° F. (20° C.), and of five minutes' duration, in order to prevent the prolongation of the fever or the occurrence of relapse, and to shorten convalescence. If relapse occurs, it must be treated according to the general formula. When the temperature no longer exceeds 101° F. (38.5° C.), defervescence being established, the baths are discontinued, and the patient should be treated as convalescent, but is to be kept in bed until the temperature has not exceeded 100.4° F. (38° C.) for four days. He may then rise, and in a short time walk in the open

air; he may prolong his promenades according to his strength, and one will be struck by the rapidity with which his strength increases after every outing. Proper precautions are to be taken against cold. As to alimentation, already during defervescence there may be added to his soup, milk, or bouillon either one or two raw eggs daily, or, a little later, one or two teaspoonfuls of scraped raw meat or a little toasted bread or biscuit, but the aliment must always be given in liquid form" (Glénard).

Dr. James Tyson's Rules for Use in the Hospital of the University of Pennsylvania in Typhoid Fever

Absolute rest in bed. Milk diet as prescribed by the physician in charge. Patient must be encouraged to void urine before the bath.

Cover loosely with a sheet, and gently lift the patient into the tub, which is placed along side of the bed. Temperature of the water usually 70° F. (21° C.). Always have an air cushion to rest the head upon; during the bath rub the patient briskly in order to keep up good circulation. A compress of ice water or ice-cap is kept on the head. At the end of fifteen minutes lift the patient into bed. Dry and lay between blankets fifteen minutes. As soon as the patient ceases to shiver, usually fifteen or twenty minutes, take the temperature. The temperature is not taken again until three hours after the bath. If it is then 102.2° F. (39° C.) or above, the bath is repeated. If the temperature is 102° F. (38.9° C.) or below, but above 101° F. (38.4° C.), it is taken again in one hour. If below 101° F. (38.4° C.) and above 100° F. (37.8° C.), take in two hours; and if below 100° F. (37.8° C.), it is taken in three hours. But whenever the temperature reaches 102.2° F. (39° C.) the bath is given, provided three hours have elapsed since the last bath. Eight baths may be given in twenty-four hours. The normal effect of a cold bath is a reduction of 2° F. (1° C.). The nurse must watch the patient's face and take the pulse frequently while in the bath. In addition to the lowered temperature, the immediate effect of the bath is to add strength to the heart and to increase the volume and slow the rate of the pulse.

In sponging, a thin film of water should be kept on the surface sponged, as it is the evaporation of this which is effectual in cooling the body.

Hemorrhage demands absolute quiet and cold to the abdomen. Minimum amount of food. Elevate the foot of the bed.

Dr. Musser's Rules

Temperature, pulse, and respiration every two hours. Sponge at a temperature of 102° F. (38.9° C.). Tub at 103° F. (39.5° C.). Have temperature of the water 80° F. (26.7° C.). Reduce to 70° F. (21° C.). Milk with lime-water every two hours. Ice-cap to head continually. Enema every other day if needed. Take temperature during the bath or immediately after, and again in fifteen minutes.

A good, portable, and folding bath-tub has been invented by Dr. C. L. Furbush, of Philadelphia. It weighs 25 pounds.

A good portable tub has been made according to Dr. Baruch's design. It has the advantages of allowing the patient's legs to be flexed as he lies in the tub, the feet resting against a double bottom which is filled with warm water. The warm water is introduced through a tube with a funnel-shaped opening near the upper margin, and is drained off through the lower faucet, the tub itself being filled with colder water. The tub is comfortable for the patient, and being higher, he is easily handled by the nurses, who work to better advantage. It is also shorter and lighter than the ordinary tub. It is a mistake in treating fevers by hydrotherapy to apply very low temperatures, very slight mechanical stimuli, and only for a short period. Such applications, according to Winternitz, raise the temperature instead of reducing it. Long cool, not cold, baths, rather

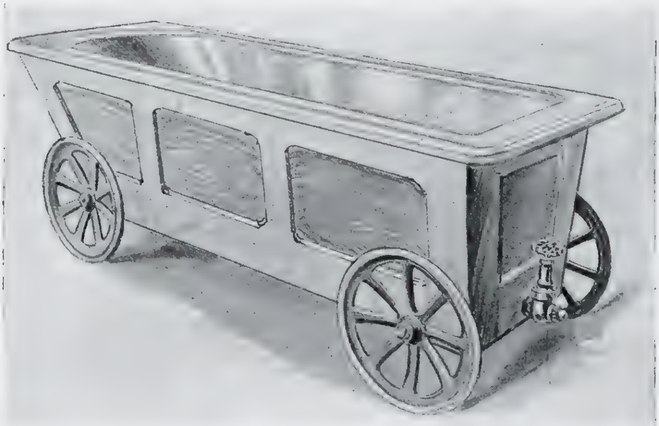


Fig. 193.—Wheeled tub (J. C. Wilson in "American Text-Book of Applied Therapeutics").

intensive mechanical stimuli, tranquil rest under adequate covering after such a bath, and its repetition at the proper time are the necessary factors. By paying attention to the bodily temperature alone the physician is apt to err by too frequent and too cold baths in the severe infectious diseases. In this manner nervous disturbances may be engendered, but by long intervals, slightly warmer water, and longer baths these complications are avoided. In typhoid a very dicrotic and rapid pulse is more important as an indication for repeating the baths than a high temperature. Very rapid pulse with a still vigorous heart calls for wet packs, repeatedly changed, which in case of a slow pulse and signs of weakness on the part of the heart would be a serious blunder. The behavior of the *vessels* is the guide for the choice of the temperature and for the length and degree of the mechanical stimulation. When the vessels display a paralytic tendency, the most energetic thermic stimulation is demanded, with avoidance of much

mechanical stimulation of the skin. This may be accomplished by brief dips and douches of quite cold water.* There is some difference of opinion as to the value of alcohol given before and after the Brand bath in typhoid fever. J. C. Wilson, Tyson, Musser, Stengel, and others generally employ it. Winternitz gives a single mouthful of wine. It has been urged, however, that nervous sensibility is lessened by its use, and the effect of the bath on the nervous system is to that extent reduced. In other words, their effects are antagonistic. It is probable that the theoretic objections to the use of alcohol under

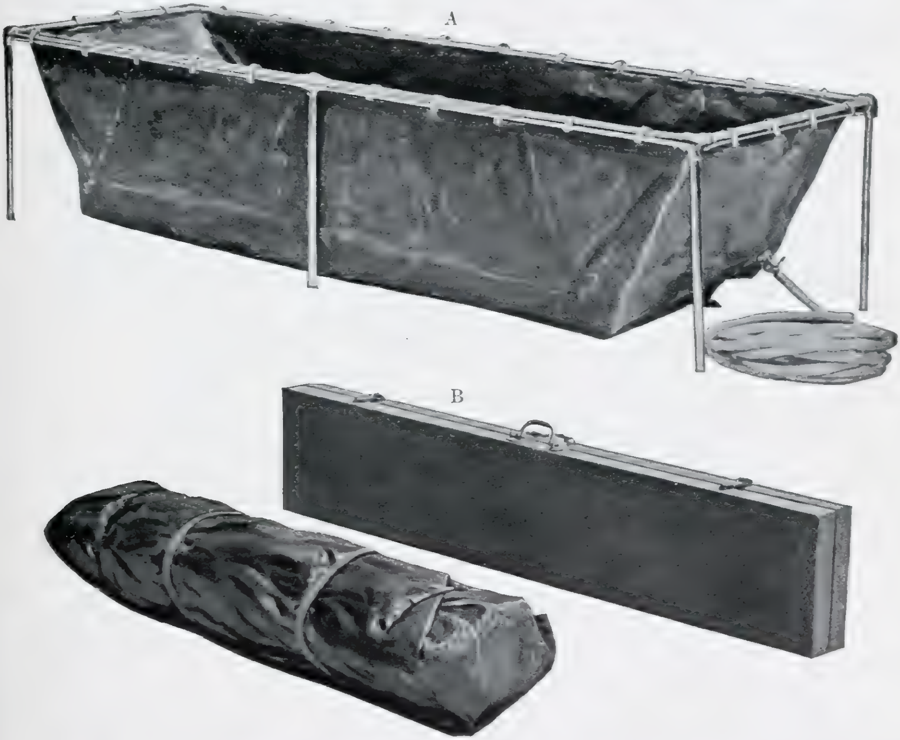


Fig. 194.—Portable bath-tub: A, Open, ready for use; B, folded, for transportation (J. C. Wilson in "American Text-Book of Applied Therapeutics").

these circumstances are not of practical importance, as clinical experience does not seem to justify the objection.

Substitutes for the Brand Method.—Dr. John H. Musser's practice in typhoid fever is to apply an ice-cap to the head when the patient's temperature reaches 101° F. (38.4° C.); cool sponging at 102° F. (38.9° C.) and a tub-bath at 70° F. (21° C.) when the temperature is 103° F. (39.5° C.) or over.

The Warm Full Bath.—This has been ardently advocated by Dr. Riess, of Berlin, who reports 809 cases of typhoid fever treated wit'

* W. Winternitz, Misgriffe bei Wasserkuren, Berlin. klin. Woch., April 3, -

bath of 88° F. (31° C.) for several hours at a time. When the temperature of the patient reaches 102° F. (39° C.), he is allowed to remain in the bath until the rectal temperature reaches 100° F. (37.8° C.). This may require from five to ten hours to accomplish, and is repeated as often as the fever requires. Its success in Dr. Riess' hands was shown by a reduction in mortality from the previous record of 10 per cent. to 8.5 per cent. Although the reduction was not over 15 per cent. of the previous mortality, the shortening of the disease was very noticeable, and its best feature. It does not reduce temperature rapidly; its efficacy is not so great as by the Brand method, but is a fair substitute.

Sprinkling is a good substitute for the Brand bath, and is often better borne. It certainly is more easily carried out and has many

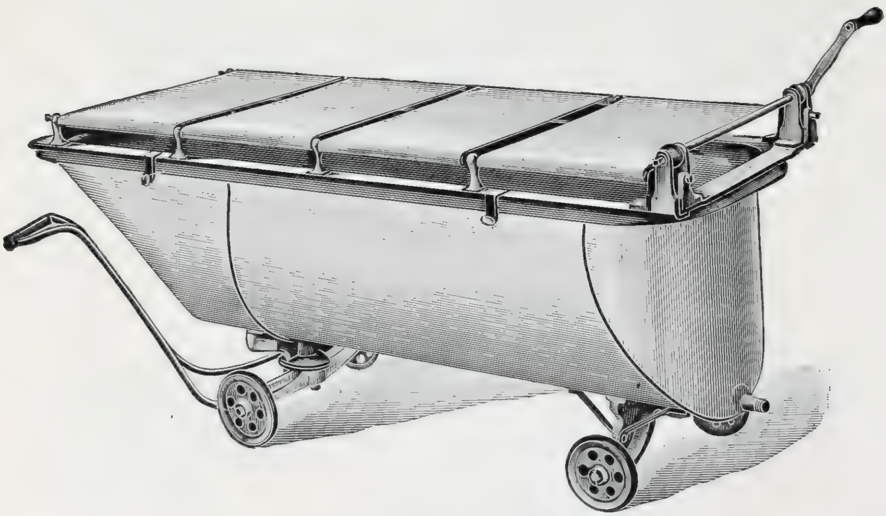


Fig. 195.—Hospital bath-tub with elevator stretcher.

advocates. First, the head of the bed is raised ten or twelve inches from the floor. Three boards as long as the bed is wide are placed crosswise under the mattress to keep it from sagging. Place a rubber sheet covered with a linen sheet under the patient, and let him have a pillow for his head, which should be covered with a turban wet in cool water. The night-dress is removed, and the water, at a temperature ten or twelve degrees cooler than would ordinarily be used in the bath, is applied from a sprinkling pot or from an irrigating apparatus provided with a large rose nozle. *Active friction* is kept up, as in the Brand bath. Some practitioners use a dry linen sheet over the patient and sprinkle this with ice water, using friction. The water should come from a height of two or three feet and should go chiefly to the abdomen and lower extremities. The surplus water should be allowed [illegible] into a pail or tub. The patient is then wrapped in a dry

Fig. 196.—Sprinkling with a watering-pot; ice rub ("ice-ironing") (Cohen).

Fig. 197.—Sprinkling with an irrigating apparatus; ice-rub. Cot should be elevated at the head (Cohen).

sheet, covered with a blanket, and rubbed. The process is repeated as in the directions for the Brand bath.

The wet-pack is another substitute, but it is likely to exhaust the patient more, as it has to be removed more frequently. The sheet bath (Lakenbad of Strasser) is preferable. The linen sheet is soaked in water at from 50° to 80° F. (10° to 27° C.), as may be desired. The head and face of the patient are bathed in ice water, and a cool wet turban is wrapped around the head. The patient's head is protected by a rubber sheet on which is placed the wet sheet, partly wrung out; the patient is now placed upon it or lifted to an adjoining cot, which has been thus prepared: while his hands are held above his head one side of the sheet is laid over the chest, close under the axilla, and beyond

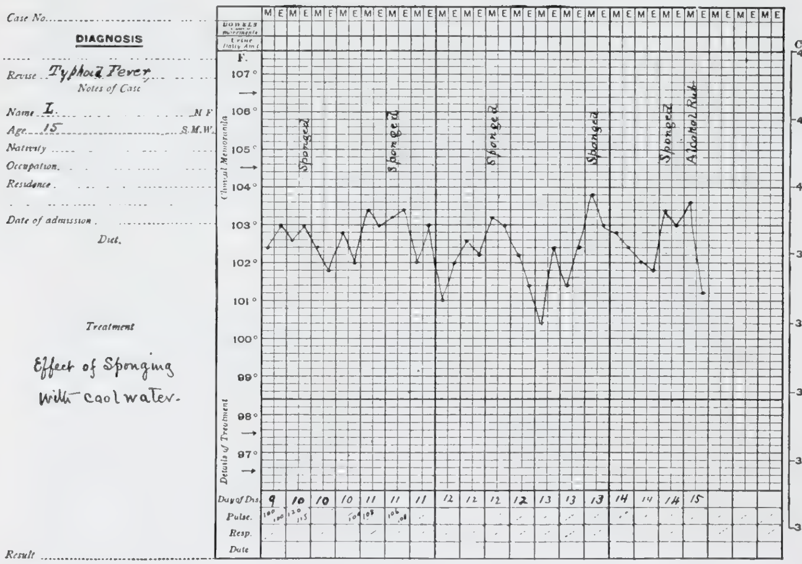


Fig. 198.

the axillary line of the opposite side, and folded in between the legs. The arms are now brought down, and the opposite side of the sheet is then passed across the body and snugly fitted in place, covering the arms and shoulders and tucked under, and the lower end is tucked under the heels. The nurse should rub the body thus enveloped, and should pour cups of water at 50° or 60° F. (10° or 15.6° C.).

As the sheet warms commence rubbing again. This is continued until the patient feels cold or shivers a good deal. More friction would obviate this. He may lie in this, if comfortable, for half an hour, the rubber sheet being withdrawn and a blanket substituted. This procedure should be employed where tubs are not to be had or when tub-baths are refused. The latter are not so generally used, even in our hospitals, as they were five years ago.

Murphy's method of proctoclysis has been used lately with success in typhoid fever.

MEASLES

The common practice is to use lukewarm baths to bring out the eruption, and, possibly, cool sponging if the fever is high. European authorities, especially Winternitz, hold that the indications are for powerful mechanical with only slight thermic stimulation. Rubbing down with a fine linen cloth wrung out of quite cold water responds to the indications in measles. The delayed eruption frequently appears at once after this procedure, and threatening symptoms vanish. The late Dr. Hiram Corson, of Pennsylvania, treated thousands of children with measles; he gave a laxative, sponged the whole body with cold water, and claimed that he had never lost a case.

SCARLET FEVER

In mild cases a lukewarm or hot bath is commonly used to favor the action of the skin; but in severe cases, where the vessels display a paralytic tendency, the most energetic thermal stimulation is demanded, with avoidance of much mechanical stimulation of the skin. Brief dips and douches of quite cold water are often surprisingly effectual. The most prominent signs of collapse and heart weakness, in this as in other affections, are the high temperature in the mouth and rectum, and clammy extremities. This condition calls at once for the application of heat to the periphery, and the abstraction of heat from the trunk. Cold packs to the trunk and heat tc the extremities will save many a desperate case.

YELLOW FEVER

Diaphoretic treatment at the commencement. Hot foot-baths with plenty of mustard are given, while the patient, with his chair and bath, are wrapped in a blanket from head to foot. This may be repeated several times in the first twenty-four hours. They favor relief of cerebral congestion and headache and invite sleep. Priessnitz packs are also applied, while hot tea is imbibed. Baths as hot as can be borne are ordered, the patient being subsequently wrapped in blankets for several hours.

The fever is most successfully treated by cold-water bandages or ice-bags to the head, repeated cold sponging of the upper part of the body or of the whole body, cold packs, tepid or cold baths.

Da Silva Ramos recommends very short cold baths; the patients are immersed for a few moments in a full-length bath filled with water at 50° to 55° F. (10° to 12° C.). This is supposed to be followed by quiet sleep, stronger action of the heart, and an increase in secretion of urine. The baths are repeated after a few hours if the symptoms

have again increased, and six such baths may be given within twenty-four hours.*

GASTRO-ENTERITIS IN INFANTS

After washing out the intestine, compresses wet with water at the temperature of the room should be used. Covered with oiled-silk, they are kept on day and night, quieting the colic and the movements of the bowels. Algid cases may be given a bath at 100° to 101° F. (38° C.), adding some mustard during the last minute of the bath, and using friction afterward. If the child's temperature rises above 101.3° F. (38° C.), a bath at 80° F. (26.8° C.) may be given for ten or fifteen minutes every three hours. If the temperature is 104° to 105° F. (40° to 41° C.), the bath should be lower—77° to 71° F. (25° to 22° C.). If the algid case does not respond by a warm glow, or a reduction of fever in the febrile case does not follow, the outlook is serious.

Enteroptosis.—Prescription 20.

Gastralgia.—Prescription 21.

Chronic Constipation.—Prescription 22, p. 496.

Diarrhea of Relaxation.—Prescription 23, p. 496.

INFLUENZA

In young children the preliminary measure should be a tub-bath, temperature, 95° F. (35° C.), reduced to 90° F. (32.2° C.) during six minutes. Cool cloths should be applied to the head, with friction of the body during this period. The body temperature should be taken before immersion in the tub, and it will probably be found that after the bath it has fallen five or six degrees. Intestinal irrigation should be instituted after the bath. Sponging with cool water (70° F.—21.1° C.) should be employed when the temperature rises above 101° F. (38.3° C.), and, in addition, an ice-bag to the head and a warm-water bottle to the feet. When the temperature rises above 103° F. (39.5° C.), wet-packs may be employed, with sheets wrung out of water at 70° F. (21.1° C.). Rectal ice suppositories may be used when the fever is excessive.

TUBERCULOSIS

The practice of bathing tuberculous patients has been advocated much more during recent years than formerly. There is a natural disinclination among the poorer classes to frequent baths, and it needs a great deal of tact to get them to follow out any hydrotherapeutic measure. In the first place, the capillary circulation in phthisical patients is usually bad; the heart's action is feeble; the skin is usually

* Diseases of Warm Climates. (Dr. B. Scheube, Trans. from German.) Edited by Dr. James Cantlie, second edition, 1903, Phila. On the other hand, A. M. Fernandez de Ybarra (Therapeutic Gazette, April 15, 1905) says that applications of ice or cold water to the head, face, hands, or back during the febrile stage are dangerous by increasing visceral congestion.

pale, sometimes slightly cyanotic, and of slow reaction. The proper application of water will generally improve the circulation, and, by acting on the vasomotor system, will stimulate the secretory function, improve the general nerve tone of the body, and save the patient from being unfavorably affected by the temperature changes of the air

We cannot do better than to repeat the advice given by I. H. Hance, who has consistently advocated these measures for the last thirty years, the first five spent as resident physician in the Adirondack Cottage Sanatorium.*

When proper hydropathic appliances are not at hand, the patient, if unaccustomed to bathing, should stand in water up to the ankles at 104° F. (40° C.), while the whole body is sponged with water at 85° F. (29.5° C.). The water for this purpose is lowered day by day a few degrees until it is used as cold as furnished from the faucet. Vigorous rubbing from a coarse towel completes the bath. To begin with, the bath may be taken at night, but afterward it is better given in the morning. After this bath has been given for a few weeks the dashing of cold water from a few feet above the head over the spine increases its usefulness. For many of the weaker patients a salt rub may be used. The patient lies naked on a heavy blanket; an attendant, not necessarily a skilled one, rubs the body vigorously with a very strong hot (110° F.—43.3° C.) salt solution, using along the spine the pure moistened salt to produce a greater reaction; then the whole body is gone over with cool water, beginning at 80° to 85° F. (26.7° to 28.5° C.), and daily lowering the temperature until 50° F. (10° C.) is reached. The time consumed will vary from twenty to thirty minutes for the bath. The hand must always be used; no mitten or cloth and only one part of the body should be exposed at a time.

This is best done at night; the patient will rest better after such a rub. The effect on the capillary circulation and the general condition will be often shown by the cessation of night-sweats, even when these are severe. In dispensary practice every patient should be instructed at least to sponge off the face and upper extremities, and the whole trunk down to the hips, with cold water, just as he washes his face on arising in the morning.

PNEUMONIA

The measures applicable to cases of influenza may also be used for pneumonia. Ice-bags are exceedingly useful applied over the affected lung. See also under Compresses, p. 487.

In the case of infants and young children, a moderately cool wet pack is useful. (See p. 465.) Cool sponging is sometimes used, but this requires manipulation, and is more liable to disturb the patient than the pack. Sponging is not so effective if there is a high temperature.

* See Transactions of the American Climatological Association, 1901, and Medical News, November 11, 1905.

For the bronchopneumonia of children hot mustard packs followed by plain hot packs are efficacious. (See p. 480.)

CEREBROSPINAL MENINGITIS

Warm baths are indicated in this formidable disease. The water temperature should be 104° F. (40° C.), and may be continued for thirty to forty-five minutes three or four times daily. Although the writer has not had any experience in treating this disease, reports of others show that there is a marked amelioration of the symptoms, and the mortality was less in those who had the baths than in those treated otherwise.* To obtain the best results the treatment should be given early. Aufrecht, in 1894, initiated this form of treatment, and Rogansky in 1904 published† the records of 51 patients treated with baths at 104° F. (40° C.) for fifteen or twenty minutes once or twice a day. Ice-bags were always placed on the head of the patient during the bath. The baths had a marked effect in relieving delirium as early as the first or second bath, and always relieved pain. Of the 51 patients, 34 were cured and 17 died—a mortality of 33 per cent. In another ward during the same epidemic 50 cases were treated by other means, and the mortality was 80 per cent. (See Warm Baths, p. 474.) Ice applications to the spine or cold applications to this region are contraindicated.

APOPLEXY

The preventive treatment is better carried out by the internal use of the waters, and the regimen adopted at Harrogate, Carlsbad, and Marienbad, than by hydrotherapy.

SUNSTROKE

See Spray Bath, p. 467; Affusions, p. 473. Ice-packs and cold tub-baths should be avoided; far better results attend the use of affusions of cool water and sponging.

NEPHRITIS

See Cold Douche, p. 470.

Von Noorden and Winternitz both favor the cold rub—"kalte Abreibung." The strong friction employed and the consequent reaction are undoubtedly beneficial; this result is impossible to obtain with warm water. In chronic parenchymatous nephritis a warm or cold wet-pack may be employed. The patient is covered with blankets, and he is allowed to sweat for an hour. The pack is then removed; he is then dried and wrapped in blankets. A warm bath at 104° F. (40° C.) may be used as an alternative.

* Albany Medical Annals, March, 1905. Article by C. G. Stockton.
† Meditsinskoye Obozreniye, October, 1904.

Sea-bathing is contraindicated in all forms of Bright's disease. (For the treatment of acute nephritis see p. 498.) Prescription D, 34.

Diabetes.—Prescriptions A and B.

HEART DISEASE *

The carbon dioxid baths are indicated in the milder degrees of circulatory disturbance, when there is slight dyspnea on exertion or moderate edema. They may also be of value in *cardiac asthma* (paroxysmal dyspnea, usually nocturnal) and in milder forms of *angina pectoris*. They are of equal service in the cardiac weakness of valvular disease and in that due to myocardial degeneration alone. They are contraindicated when there is oppressed breathing, with the patient at rest, or when edema is marked.

The circulatory organs can be acted on reflexly by stimulating the sensory nerves of the skin, and the most powerful stimulus of the cutaneous sensory nerves is the carbon dioxid bath. The peripheral vessels are narrowed, but as there is an increased flow of blood through them, the skin becomes reddened and there is a pleasant sensation of warmth produced. The blood-pressure is elevated. The altered distribution of the blood in the body is an aid to the proper functioning of the heart. The breathing becomes deeper, and this also accelerates the flow of blood.

If the bath is not too strong, it produces a slight rise in blood-pressure when given at a temperature between 85° F. (29.4° C.) and 92° F. (33.3° C.). In treating heart cases the physician should carefully note the immediate effect of the treatments. He should be present occasionally when the strength of the bath is increased. It is important to percuss out the cardiac outline before and after the bath.

ARTERIOSCLEROSIS

Hot baths are recommended because they alter the distribution of blood-pressure by unloading the internal organs and increasing the amount of blood in the skin. Hence we may expect prompt relief in cases of pain associated with internal gout, which is such a frequent factor in arteriosclerosis. Sleeplessness, which is often a troublesome symptom, is often overcome by hot baths.

Hot baths increase oxidation, the body-temperature rising according to the heat of the bath and the length of immersion. After a bath of 104° F., lasting ten minutes, the rise in the body-temperature amounts to 1° or 2° F., and persists for about two hours, the temperature returning gradually to the former level. It is not due to increased heat-production, but to increased storage and direct warming of the blood. The hot bath increases the elimination of

* The indications for hydrotherapy in diseases of the heart have been discussed in connection with remarks on the Nauheim baths (see p. 480), and for acute endocarditis see p. 490, under Fomentations. See also prescriptions H and I, p. 498.

waste-products; it is followed by perspiration, which, if the bath is not over 104° F., is not heavy, but the skin becomes moist after twenty or thirty minutes, and continues so for about one or one and a half hours. If the temperature after bath is raised to 106° or 108° F. (41.1° or 42.2° C.), the perspiration is profuse. After such a bath the patient should be kept in bed. The hot bath, by congesting the skin, reduces blood-pressure. The systematic employment of the hot bath in arteriosclerosis daily establishes an increased vascular habit of the skin, thus permanently lowering pressure. It should not be given in a haphazard manner, but the temperature and time of immersion should be carefully regulated. An increase of 1 degree in the temperature may bring about unpleasant effects in some cases. In every instance it is necessary to ascertain the reaction of the individual. In cases of arteriosclerosis hydrotherapy should be conjoined with massage and passive and active movements. Alcohol rubbing is admirable.

It is generally held that cold-water applications, especially cool baths with carbonic acid gas, are contraindicated; but Groedel holds that this is an error. There are many cases of arteriosclerosis in which the blood-pressure is very little above normal, so that cold applications are permissible. Such cases must be considered on their individual merits. The oxygen bath, lately introduced, is claimed to be especially suited to cases of arteriosclerosis. The average patient will bear a bath of 102° F. (38.9° C.) for ten minutes, during which a little rubbing may be employed. The determining factor in the management of a patient is the condition of the left heart, the quality and loudness of the first and second sounds. Without a vigorous left heart, the hot bath must be used with caution.

RHEUMATISM—ACUTE ARTICULAR FORM

In the hyperpyrexia of acute rheumatism, in cases of the cerebral type when the temperature suddenly rises from 102° or 103° F. (38.9° or 39.4° C.) to 105° F. (40.6° C.), cold baths should be employed at once. The water having an initial temperature of 85° to 90° F. (29.4° C.), is gradually lowered to 65° or 60° F. (18.3° to 15.6° C.). If the patient is unconscious, he should be placed in water at 65° F. (18.3° C.) without delay, the duration being governed by the fall of the temperature to 101° or 100° F. (38.2° or 37.8° C.). It will probably fall from 1 to 3 degrees more after removal from the bath. In the first bath a longer time is usually required to effect the same amount of temperature reduction than in subsequent baths—perhaps a half-hour or more. When removed from the bath, the patient is dried and some stimulant given. If necessary, the bath may be repeated, but sometimes one will suffice. The cerebral form of rheumatism is so serious in itself that there are practically no contraindications.

The Clinical Society of London, through a committee, has reported

that only one patient recovered among those observed, having a temperature higher than 106° F. (41.1° C.), in which the bath was not employed; while of the bathed cases with a temperature of over 106° F., nearly 60 per cent. recovered. Several cases are on record in which the temperature reached 110° F. (43.4° C.), and in which recovery has followed the use of the baths. In some instances 26 baths have been employed.

These baths not only reduce the temperature, but they quiet the delirium; if comatose, the mind becomes clear, the pulse is reduced in frequency, and normal sleep returns to relieve the nervous system. When baths for any reason cannot be used, the patient should be sponged with ice-cold water or the cold wet-sheet pack should be employed; or he should be placed on a cot protected with rubber and soused with water from a large sponge.

In cases of acute rheumatism, very active measures, such as douches, or attempts at passive motion or massage, are distinctly contraindicated.

RHEUMATISM—CHRONIC ARTICULAR FORM

The value of thermal springs in the treatment of chronic articular rheumatism and the arthritides is recognized the world over. The chief factors are the systematic application of heat, the manipulation practised in the baths, and the consequent improvement of the circulation in the parts affected. At the Hot Springs of Virginia I use the waters at temperatures from 100° to 104° F. (37.8° to 40° C.). The patient for whom such treatment may be deemed suitable is usually placed in a full bath containing about 80 gallons of water constantly flowing in and out the tub. His head is covered with a turban wet in ice water; an attendant rubs the limbs and the body while the patient lies in the bath, and in successive baths applies movements, graded in force, to the affected joints. In patients accustomed to hot bathing it is possible to begin with a temperature of 104° F. (40° C.), which in most cases is quite agreeable. After eight or ten minutes of the full bath he is dried and laid on a couch, where he is closely packed in a hot, dry sheet and inclosed in three or four hot, dry blankets and allowed to remain for eight or twelve minutes, after which he is rubbed vigorously with alcohol for five minutes. On the fourth day the bath is omitted, and afterward the baths include a preliminary hot douche applied all over the body excepting the head, the anterior chest, and abdomen. The elements of this bath are naturally adjusted in time and in force to the needs of the patient, as may be determined by his medical adviser. Cool sponging or a cold douche is frequently employed after the pack. General massage is also employed in suitable cases some time during the day, but not usually directly after the bath. (See prescriptions D and E, p. 498, and Nos. 11 and 13, 14, and 15, p. 494.)

* See James Stewart, A Text-book of Applied Therapeutics, W. B. Saunders Co., p. 535.

The rationale of this method of treatment lies in the better circulation established and in the increased mobility of the tissues involved. Exudates in the fibrous investment of joints, in the sheaths of tendons, and in the muscular tissue create more or less disability, and if untreated by external agencies, tend to increased pain and stiffness, if not to fixation of the limb. In the case of spinal arthritides even more serious fixation and deformity are likely to ensue, and hence the usefulness of general physiologic measures like hydrotherapy and massage. In a systematic course of bathing the secret of success lies in a judicious education of the patient to bear heat and manipulation in an increasing gradation; mild measures at the outset secure confidence, and later a degree of manipulation is possible depending on the special characteristics of the case in hand that would not otherwise be secured.

Fig. 199.—Hot, dry pack, Hot Springs, Virginia.

It is well known that when limbs are immersed in water less pain is elicited on active or passive movements than when the same movements are practised in the usual atmospheric medium. This fact is taken advantage of to the fullest extent, and constitutes one of the advantages of the full bath in these cases. The skin acts more freely, and becomes pliable and free from all excreting matter. The blood-vessels of the part, both superficial and deep, are enabled to take up and carry off any exudates or infiltrates, which always exert a restrictive influence on the motion of the structures involved and impair a proper interchange of circulation; therefore, we have the great advantage of improved nutrition.

Secondary muscular atrophy, which is commonly observed in

chronic joint disease, may be forestalled if treatment is started early, and especially when massage is used judiciously in connection with hydrotherapy.

In very chronic cases of gonorrheal rheumatism we should attempt to cause absorption of inflammatory deposits about bursæ, tendons,

Fig. 200.—Reapplying the wet cold turban in the hot dry pack.

and synovial sheaths. For this purpose douches, especially the warm or hot jet douche, the Scotch douche, and massage may be employed.

GOUT

The outbreaks of acute arthritis which so often follow spa treatment depend upon the thermal action of the mineral baths. Similar attacks follow the use of plain hot-water baths devoid of mineral properties. Garrod has seen a severe attack of gout brought on by taking a hot bath soon after dinner. Hot-air baths in cases of suppressed gout may determine an acute attack. These acute phenomena are usually interpreted as preparing the way for the elimination of uratic deposits, the ultimate result of which is beneficial; conversely, the absence of any reaction in a case of gout after the adoption of thermal baths does not augur well for benefits to be derived from treatment.* Warnings should be given the patient of the likelihood of acute symptoms supervening. In pale and debilitated patients warm baths may be employed before retiring, and special efforts should be made to prevent chilling the patient. (Prescriptions Nos. 1, 2, and 3, p. 493.)

* See article by Francis Hare, M.D., Med. Record, June 17, 1905.

ARTHRITIS DEFORMANS

In order to bring about absorption of the exudates and restore motion of the affected joints it is a common practice in Europe to employ hot-air baths or compresses of fango or moor, hot wet packs, hot sand-baths, and electric-light baths. Satisfactory treatment can be obtained at Aix-les-Bains, Aix-la-Chapelle, and Battaglia. In New York City all these forms of treatment are given at the Fango Institute, 69 West 90th Street. After these applications there is an increased sweat production, followed by a moderation of the symptoms, reduction of the swelling, and increased mobility of the joints. When the disease has progressed so far as to have produced hyperplasia with deformity, the prognosis is unfavorable, no matter what means are employed. Amelioration may follow hydrotherapy, though cure may be impossible.

Most observers agree that the use of ordinary hot baths is not to be recommended, excepting in the early stages. When ordinary baths are not employed, it may be better to use the passive congestion treatment (compression by rubber bandage above the joint), devised by Professor Bier, of Bonn. We have seen improvement follow the use of the hot-air cabinet, followed by circular, jet, Scotch, and fan douches.

ALCOHOLISM

This is one of the most favorable fields for hydrotherapy. In acute cases the Turkish bath yields, as a rule, immediate results. If this is not convenient, a prolonged soaking in the warm full bath at a temperature of 100° to 102° F. (37.8° to 39° C.), followed by friction and rest in bed, may be employed.

Chronic alcoholism is best treated by the use of tub-baths at 102° to 104° F. (39° to 40° C.) for ten, fifteen, or twenty minutes, followed by packs in hot blankets for similar periods. Cases demand treatment in accordance with the general physical condition. The corpulent, robust man may or may not have a good cardiac and circulatory system, and the immediate effect of these procedures must be observed. If they are well borne, they may be pushed to the higher limit and followed by cold sponging or cold douches.

Delirium Tremens.—The late Sir William Broadbent was a strong advocate of cold affusions in these cases. The patient is stripped naked and lies on a blanket over a water-proof sheet. A copious supply of ice-cold water is provided, and a large bath-sponge dripping with the iced water is dashed violently on the face, neck, chest, and body as rapidly as possible. He is then rubbed dry with a rough towel, and the process is repeated a second and third time. The patient is now turned over, and the wet sponge is dashed on the back of the head and down the whole length of the spine two or three times, vigorous friction with a bath-towel being employed between the cold-

water applications. By the time the patient is dried and made comfortable he will probably be fast asleep.

In a case cited, after a week of continuous indiscriminate drinking the patient had delirium tremens, with characteristic hallucinations; he was violent and had less tremor than is usual in delirium tremens. A complication which almost precluded recourse to opiates or sedatives was the presence of a large amount of albumin in the urine.

The treatment was effectually carried out, with the expected result of sound, refreshing sleep and speedy recovery. The albuminuria gradually disappeared.

Sir William employed cold affusion in this way even when there was extensive pneumonia with the delirium tremens. When the patient wakes up the tremor is gone, the relaxed, perspiring skin is warm and dry, and the weak, flickering pulse has recovered tone. The graduated bath has much less effect than the plunge into cold water, and may have no effect unless cold affusion is applied to the head.*

Hot baths may be adopted in chronic lead-poisoning and morphin and tobacco habitués. Tonic measures and the use of the hot-air cabinet, followed by the circular douche, jet, Scotch, and fan douche, and an alcohol rub will be required where there is debility, and especially after a course of tubs and packs.

The internal use of waters, especially those containing magnesium sulphate, aids in the treatment of alcoholic patients. Among the most successful resorts in America for cases of this class are French Lick and West Baden, Indiana. It is the custom there to rise early—about 5 o'clock during the milder season—and drink several glasses of the Pluto Spring Water. It is laxative and diuretic, and has the great advantage of annuling, for a time at least, the craving for alcoholic liquors. The author has had repeated testimony on this point, and has been impressed with the results which have been obtained in a comparatively short period. Several quarts or even gallons of this water are taken daily by the thousands of visitors who visit these resorts from Chicago, St. Louis, Cincinnati, and other cities in the middle west. (Prescriptions 13 and 16, p. 494, and, later, prescription D.)

CHOREA

The child's face should be washed in cool water and placed gently in a tub of water of 90° to 98° F. (32° to 36.4° C.). This temperature will prove agreeable at the start. The water can be cooled not more than 10 or 15 degrees during the bath. Children can usually be amused for an hour with playthings or floating toys, so that the time will pass rapidly. The bath may last an hour and be repeated once in the day. Toward the end of the bath there should be superficial massage of the arms, legs, and trunk, and after removal from the bath the child will probably take a nap. Dr. W. C. Hollopeter has reported

* Abstract of a Therapeutic Note in the British Medical Journal for July 1, 1905.

good success by this method without medication. Coincident heart disease offers no contraindication. (Prescription No. 2 may be used, without daily lowering of temperature.)

ANEMIA; CHLOROSIS; CONVALESCENCE FROM ACUTE ILLNESS

In treating these affections the aim is to stimulate all the sources of body heat to a powerfully increased function. It is a mistake to use water in baths at too high a temperature, *e. g.*, above 101° to 102° F. (38.3° to 39° C.). The first step is to warm the body, applying afterward vigorous brief thermic and mechanical stimulation of the nerves. Nothing accomplishes this so well as the hot-air cabinet, succeeded by the circular douche, jet, and Scotch douches, followed by an alcohol rub.

The Turkish bath is also useful in promoting good circulation and improving the condition of the blood in anemic cases, particularly if associated with a redundance of fat. In this connection massage is a most valuable adjunct. The drip-sheet may be used when other measures cannot be adopted (Prescriptions Nos. 1, 2, and 3).

NEURASTHENIA

Most neurasthenics are benefited by hydrotherapy. Nearly all the various baths that promote healthy reaction may be employed. The best of these are the drip-sheet, alternate hot and cold sponging of the spine, the tonic treatment by means of the hot-air cabinet, the circular douche, jet, Scotch, and fan douches, and subsequent rub.

Cool or cold water bathing is not always beneficial to the neurasthenic, at least at first. Cases of chronic fatigue are poor subjects, just as it would be improper to give a healthy person, greatly fatigued by exercise, a cold bath. If such be given, there may be a secondary feeling of drowsiness or lassitude. If any hydrotherapeutic measure at moderately low temperature, applied for neurasthenia, produces unpleasant effect, it would probably be corrected by raising the temperature, lowering the pressure, and shortening the bath.

Much can be done by way of educating the resistive powers of these patients. A routine bath is always to be deplored, but especially here. Individualization, education, and persistence should mark the treatment of these cases. Just as in applying electricity to a neurasthenic man or woman, it is safer at first to apply the electrodes without current, so unusual care should be exercised that no shock from either very hot or cold water should be possible. Dr. Baruch told the writer that he considered his principal contribution to the technic of hydrotherapy to be the educational bath. To render this feasible by definite gradations of pressure, temperature, and duration, he had the douche table constructed which is identified with his name. (See p. 473.) In other words, the successful treatment of these cases depends on intelligent dosage.

In carrying out treatment with the apparatus referred to the author directs the use of the hot-air cabinet until perspiration is well established; this takes six, eight, or ten minutes at a temperature of 170° or 180° F. (77° or 82° C.). Then one or two minutes in the circular douche, the temperature being reduced in the time allowed from 105° to 80° F. (40.5° to 26.5° C.), the pressure being 15 pounds. Then the jet douche from fifteen to thirty seconds, reduced from 85° to 75° F. (29.5° to 24° C.) at the same pressure; followed by the fan douche at the same pressure, and at 75° F. (24° C.). From day to day the temperature of the circular douche is reduced one or two degrees until 65° or 60° F. (18.3° or 15.5° C.) is reached; the pressure is raised to 20 pounds. The jet and fan douches are correspondingly lowered. We can step down in temperature and step up in pressure more rapidly in some cases, especially those in which good reaction takes place in the first or second bath. As in all other educational processes, some progress rapidly; others are more sluggish. Hence the physician must be in touch with the operator, receive immediate reports, or, better still, if possible, watch the procedure. In hospitals, sanatoria, and health resorts this oversight is better systematized than elsewhere, and often accounts for the better results obtained. Prolonged hot baths, the hot spout, and hot packs are not suitable measures in neurasthenia; even when followed by a cool shower or douche, the ultimate effect is bad. The drip-sheet is a much better alternative. (See prescriptions Nos. 1, 2, 3, 29, A, B, and C.)

HYSTERIA

See prescriptions Nos. 1, 2, 3, 29, A, B, and C.

SEXUAL NEURASTHENIA

Good results follow cold bathing in the morning. The patient is made to stand in the bath-tub, which contains warm water, while the cold water, preferably at a temperature of 55° to 70° F. (12.8° to 21° C.), according to the temperature of the available supply, is made to flow from the occiput to the spine. Three minutes at first, and later five minutes, suffice. The patient should rub himself briskly. Good food with moderate doses of strychnin or phosphorus aid the treatment. (Prescriptions B, D, Nos. 19 and 25.)

INSOMNIA

The warm bath, 90° to 100° F. (32.2° to 37.8° C.), or full hot bath at bedtime may be first tried. The patient's head should be surrounded with a cold wet cloth. After about fifteen to thirty minutes the patient is quickly dried, without much rubbing, and he is then given a cool foot-bath with brisk rubbing of the feet, and the head is wet with cool or cold water. He is then to be put to bed.

The cold wet-pack with friction of the entire body may also be tried should this fail. In cases attended with overactivity of the cerebral circulation the cool spinal douche with brisk rubbing of the body and cold applications to the head should be used.

The drip-sheet may succeed in cases in which the foregoing measures fail.

Rationale.—Primary effect: Contraction of the capillaries of the surface and hyperemia of the brain and internal organs. Secondary: Hyperemia of the skin; depletion of the brain. (Prescription 31.)

HEADACHE

Prescription 30. Cold foot-baths or cold douches to the feet if due to congestion.

INSANITY

Systematic treatment of the insane by means of hydrotherapy has been carried out with considerable success in this country at the United States Government Hospital for the Insane, Washington; at the McLean Asylum, Waverly, Massachusetts; The Butler Hospital, Providence; at the Pennsylvania Hospital for the Insane, Philadelphia; at Manhattan Hospital for the Insane, Ward's Island, New York; The Eastern Maine Hospital for the Insane, Bangor, Maine; also at private institutions, such as Dr. Parsons, at Ossining, Dr. Bond's house at Yonkers, and the Sheppard and Pratt Hospital, Baltimore.

One of the first to report on the results of treatment was the late Dr. G. W. Foster. His report, published in 1899,* gives the results of treatment in 12 epileptics and 21 cases of paresis. The average duration of treatment of the epileptics was over seven months. In every case but one a marked improvement, both mental and physical, followed. The average loss in number of fits was 41 per cent. The cases of general paralysis were naturally not so satisfactory, although 3 were reported arrested and 6 improved. Of course, in the absence of precise objective data by which a comparison may be made of the patient's mental condition before and after treatment the judgment of the medical attendant must alone be relied upon. Dr. Foster reported 3 cases of acute mania recovered; 2 of acute dementia; 1 acute melancholia, and 1 a morphin habitué. Dr. B. R. Logie has continued this method of treatment at the Government Hospital during the last four years, applying it to all forms of insanity. In mania with depression he believes the disease has been shortened and the symptoms modified from the beginning, and nearly all these cases have made rather rapid and good recoveries, prolonged periods of excitation having been rare.

In a personal communication dated February 21, 1905, Dr. Logie writes:

* American Journal of Insanity, vol. lv, No. 4.

"In all cases of excitement and depression I would ofttimes be able to relieve the symptoms. In epilepsy I believe that during the period of active treatment in a number of instances the attacks were greatly reduced in number, and perhaps not so severe at the time of recurrence. In the paretic and the large class of chronic insane—including, of course, the dementias—I have been able, by keeping in first-class order the physical condition, and by especially directed efforts toward such symptoms as excitement and depression, to render them comfortable, and perhaps to prolong their existence. Personally, I approve of the treatment, and believe that it stands today without a rival. My methods of applying the treatment are few, owing to the fact that experience has apparently demonstrated that there are only a few procedures which it is really worth while to use. As a matter of routine, then, I have adopted these, and alternating them to suit my case, have confined myself almost exclusively to their use. The most prominent of these procedures are as follows: first, the cold wet-pack; second, the hot-box; after each of which I am in the habit of dressing the patient either by cold towels or, preferably, the Scotch douche. In cases that are very much excited I use, as a rule, a warm bath, temperature about 112°, followed by a prolonged submersion in the neutral bath." (Prescriptions 31, 33, B, and C.)

In the acute toxic insanities tonic cold applications should be employed.

MELANCHOLIA

In the incipient stage prolonged warm baths. In stuporous melancholia a mild tonic bath, hot-air cabinet, and circular and jet douches may be useful. (Prescriptions A, B, C, 3.)

NEURALGIA OF THE FIFTH NERVE

Neuralgia of the fifth nerve and occipital neuralgia are benefited by warm baths. It is well known that neuralgias are less severe in dry and warm weather, and this points to the use of hot-air and warm baths in connection with favoring climates. Such cases can no doubt be more successfully treated in Egypt, Sicily, and the Riviera, or at Virginia Hot Springs. The relation of chronic constipation to neuralgia should not be overlooked, and hence the use of purgative waters, like those of Saratoga, Crab Orchard, French Lick (Pluto), Abilena, Apenta, Hunyadi, Rubinat, and other well-known aperients will often aid in the cure. In cases where neuritis is not present, the Aix massage bath with the douche applied to the painful part is sometimes of great value. This form of treatment is practised at Aix-les-Bains and Aix-la-Chapelle. (Prescriptions 10, 33.)

SCIATICA

The use of the jet douche is valuable. The patient should have the preliminary hot-air or electric-light bath at 170° F. for about six or

eight minutes, or until perspiration is established. The jet douche is applied for about thirty seconds to one minute at a temperature of 90° F. (32° C.), reduced to 60° F. (15.5° C.) over the spine and to the seat of pain. The Scotch douche at 105° F. and 60° F. (40.5° and 15.5° C.) is then applied to the spine. The pressure should be from 15 to 20 pounds. This produces great hyperemia of the skin.

Hot fomentations are also useful where douches cannot be employed. At Buxton, England, subacute cases are treated by what is called the "half combined bath." The patient sits in a vapor bath, which comes up to the waist-line only; this, while not exhausting the patient as much as the full vapor bath, allows a higher temperature to be borne by the affected parts. Thus, a temperature of 115° F. (46° C.) can be tolerated with advantage for from ten to fifteen minutes. At the end of this time the patient sits in a bath of the Buxton thermal mineral water heated to a temperature of 95° F. (35° C.) for eight minutes, and during the last three minutes a hot undercurrent douche at 102° to 110° F. (39° to 43.3° C.) is applied to the affected limb.

In affections of the brachial nerves the full combined bath is used, or if the patient is too weak for this, the arm alone is placed in the vapor box before he goes into the immersion bath. (Prescription F.)

PERIPHERAL NEURITIS

Fomentations will relieve pain; but after the acute stage has passed, the Scotch douche and fan douche should be used to improve the circulation and improve the tone of the muscles. For traumatic neuritis the ice poultice is useful. (See p. 488.) (Prescriptions 17, 18.)

OBESITY

There is no single remedy for obesity. We naturally use every method available in these cases. Diet, exercise, both active and passive, and hydrotherapy should be combined. The object of hydrotherapy should be to develop and promote elimination. We have the skin, the bowels, kidneys, and the lungs to work upon. It is obvious that all measures that stimulate the appetite, invite sleep, and promote constructive metabolism would defeat our ends. The plan which I usually adopt at the Hot Springs of Virginia is for the first three days a full bath at 104° F. (40° C.) for twelve, fifteen, or eighteen minutes, according to the strength of the patient, followed by a hot, dry pack for similar periods, a cool spray, and an alcohol rub. The patient then is partly dressed, and rests for twenty minutes, goes to his room, and lies down. If this occupies a morning hour, he devotes the afternoon to walking, golf, or mountain-climbing, as the physical condition of the patient warrants. In the evening he has massage for an hour or massage may be given before rising. Walks up a 5 and 10 degree grade are provided, so that systematic exercise may be prescribed, and it is remarkable what may be done by men and

women who are gradually led to take up this form of physical training. The accompanying chart illustrates the results obtained by the author in a case under the combined treatment. (Prescription 18, with time of bath and pack doubled, 35.)

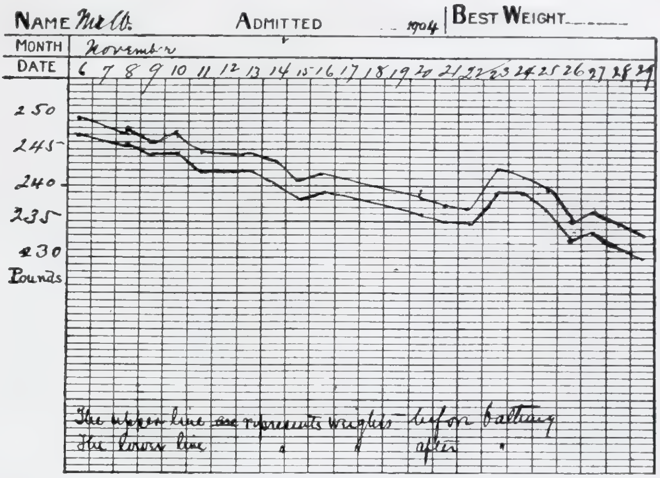


Fig. 201.—Weight chart showing reduction of weight while bathing.

Water-drinking should be restricted between meals and at night, but may be allowed at the table.*

SYPHILIS

The Hot Springs of Arkansas, the Mt. Clemens Springs, and the baths of Aix-la-Chapelle, France, are the most famous for the treatment of syphilitic affections. All the bathing establishments at Hot Springs, Arkansas, are on property belonging to the United States Government. At Hot Springs, Arkansas, it is usual at first to order a bath of six minutes' duration at a temperature of 93° to 95° F. (34° to 35° C.), to be gradually increased in successive baths to 100° F. (37.8° C.) for ten minutes. After the tub-bath packs in hot blankets, two, three, four, or five blankets may be employed. Alcohol rubbing is not used, as it is believed to prevent elimination through the skin; cold douches are not usually given, although cold cloths may be applied to the head if there is a tendency to headache.

Vapor baths may be medicated with either calomel or sulphur. In treating early syphilis, especially when there are extensive eruptions, 15 to 30 grains of calomel may be volatilized by means of special apparatus, with just sufficient water to excite the skin to moderate

* For a discussion of this subject see Obesity, Carl von Noorden, 1904.

action. Preliminary steaming is not necessary, as the heat required to volatilize the calomel is enough to excite sufficient perspiration. For sulphur vapor baths, one or two ounces of sublimated sulphur may be used. Patients with syphilis, rheumatism, and acne may be benefited by such treatment. (Prescription 18. Later give 19 as a tonic.)

HYDROTHERAPY IN SURGICAL AFFECTIONS

Germany and Austria are far in advance of England or America in the systematic use of hydrotherapy. In the Hydrotherapeutic Institute of the University of Berlin, opened in January, 1901, 70,000 patients were treated in the first four years; 93 skilled attendants are employed; hundreds of physicians from Germany and other countries have been educated in hydrotherapeutic methods. In the Royal Wilhelms Heilanstalt in Wiesbaden about 4000 surgical cases are treated yearly, and in a single year over 50,000 baths are given to all classes of patients. The chief ailments treated are chronic articular rheumatism, bruises, sprains, fractures, dislocations, and wounds. Thermal baths are most commonly used; partial thermal baths, thermal douches, and fango treatment are also frequently employed; cold douches and steam douches, less frequently. Hydrotherapy is used in connection with massage and the Zander apparatus. The waters employed abroad are usually only a little above the bodily temperature. Mineral steam baths, baths or douches in mineral water, or of gaseous waters are used, and always in connection with the internal use of some of the springs. The greater heat capacity of mineral mud and sand baths is made use of. The underlying principles in treating surgical conditions are the same as in treating fevers—increased oxidation is brought into play.

Acute diseases of the bones and joints are, generally speaking, poor subjects for hydrotherapy. In all these affections a chronic process follows the acute stage, but treatment in this manner affords the best results. Acute infectious osteomyelitis, in which the growing skeleton and all its parts are affected, affords a conspicuous example. Pus infiltrates the bones, causing necrosis, and baths may accomplish great good. Stiffened joints resume their former mobility; the atrophied muscles are afforded a better circulation, and strength returns as formerly; but more than this, it favors the separation of dead bone from the surrounding healthy tissues. For such cases warm baths of long duration for several weeks are required.

In tuberculosis of the bones and joints we naturally give preeminence to the influence of climate, especially favorable marine climates; and, second, to the use of salt or mud baths containing iodin and bromin. Dr. Fedor Krause, of Berlin, who has given a great deal of attention to this subject, attributes to such baths a direct influence on bone tuberculosis.*

* Berlin. klin. Woch., No. 14, 1905.

HEMORRHOIDS AND PROSTATIC DISEASE

Prescription 24.

SKIN DISEASES

Mineral waters have always had a reputation for the cure of skin diseases. Few advertisements of mineral springs fail to mention their efficacy in such cases. There must be some foundation for this belief, which has existed from time immemorial. To get rid of fecal accumulation is the first step in the treatment of inflammatory diseases, such as eczema and acne. We may thus in many cases get rid of the true causes of these affections by administering the purgative waters, such as Pluto, Abilena, Crab Orchard, Hunyadi, Villacabras, Püllna, and arsenical waters. Waters as free as possible from sodium chlorid should be chosen.

In the more refractory skin diseases, such as *psoriasis*, the internal use of arsenical waters, such as those of Royat, La Bourboule, Roncegno, and Levico, are useful. The latter is the strongest arsenical water known, containing about $\frac{1}{12}$ grain per pint, as well as persulphate of iron. Not more than a tablespoonful well diluted is usually prescribed, or about $\frac{1}{380}$ grain of arsenious acid. La Bourboule contains about 2 grains of sodium arseniate in the gallon (0.028 to 1000 c.c.). The Royat Spring is richer in iron than that of La Bourboule, but contains only one-sixth the amount of sodic arseniate, or about $\frac{1}{3}$ grain per gallon.

Sulphur waters have been successfully used in treating psoriasis. They are usually applied externally. Those best adapted for the purpose in America are Richfield Springs, Sharon Springs, in New York; White Sulphur Springs, in Virginia. In England, those of Harrogate and Strathpeffer, in Great Britain; Aix-la-Chapelle, Germany; Schinznach, Switzerland; and Baréges in the Pyrenees, in France.

Thermal baths in weak alkaline water are also used. Those of the Warm, Hot, and Healing Springs in Virginia, and of Hot Springs, in Arkansas, belong to this class. Corresponding baths are found at Bath and Buxton, England; at Lenk, Switzerland, altitude, 4500 feet; Canton of Valais; at Aix-les-Bains, France. The last named have a temperature of 112° to 116° F. (44.5° to 46.1° C.). The waters of Plombières in the Vosges Mountains in France are used in cases of psoriasis as well as pemphigus. They are applied in a continuous bath, the natural temperature of 117° F. (47.2° C.) being moderated for baths. The altitude of Plombières is 1310 feet, and the climate is bracing.

Skin diseases may require variously modified baths. The following may be used in 30 gallons of water.

Emollient baths: Bran, 2 to 6 pounds to 30 gallons of water; Potato starch, 1 pound; gelatin, 1 to 3 pounds; linseed, 1 pound. These are useful in erythematous, itchy, and scaly diseases.

Alkaline baths: Bicarbonate of soda, 2 to 10 ounces; carbonate

of potash, 2 to 6 ounces; borax, 3 ounces. The bicarbonate may be used with bran liquor, made by infusing a gallon of bran. Useful in eczema, psoriasis, urticaria, lichen, and prurigo, where there is much local irritation.

Potassium sulphid, 2 to 4 ounces to each bath. Another formula, useful in itch, chronic eczema, lichen, and psoriasis, is: Precipitated sulphur, 2 ounces; sodium hyposulphite, 1 ounce; dilute sulphuric acid, 1 ounce, mixed in a pint of water and added to the 30 gallons of the bath.

The wet-pack is useful in extensive psoriasis, to remove scales and diminish hyperemia.

Simple vapor and hot-air Turkish baths are not especially valuable; they are, as a rule, injurious in eczema, which forms the largest class of diseases of the skin.

CLIMATOTHERAPY AND HEALTH RESORTS

By Henry Sewall, M.D.

The favorable influence of climatic change on the course of certain diseases and as an aid to convalescence has been observed from the earliest times, and the use of this means of treatment probably antedates medical history. The conclusions from the vast fund of experience accumulated within this field of therapeutics have alone stood the critical test of developing knowledge, and until lately no one thought of doubting that climatic factors are as potent to modify favorably or unfavorably the exercise of physiologic functions of animals as of plants. The modern conception of therapeutics has enthroned the *vis medicatrix naturæ* as the final refuge of the health-seeker, and the administration of drugs in disease is admittedly abortive for good except as enhancing the metabolic powers of the tissues. The use of climate in the treatment of disease particularly appeals to reason, since no one holds that climate is a *thing*, or doubts that it is merely an environment capable of modifying metabolism. The very fact that many diseases depend, to a degree, upon seasonal variations for their inception is strong evidence that the broader conceptions of climatology must be reckoned with in prophylaxis and therapeutics. But of late years there has been a tendency in some quarters to underrate, if not deride, the potency of climatic therapeutics, and there is danger that the scientific perceptions of the near future may be founded upon monocular vision of admitted facts.

Perhaps the greatest therapeutic achievement of all time has been the establishment of the broad fact that the living body resists the inception and extension of the tuberculous process, if at all, when stimulated by a return to nature—to a life in the open air. But, admirable as are the virtues of what may be called the "back-yard treatment" of tuberculosis, it is necessary, astonishing as it may seem, to insist that the meteorologic qualities that lead to healing in open city-spaces may be found more intense and less adulterated in other chosen localities.

It may be taken as axiomatic that those therapeutic measures are most commendable that tend to restore the body to its highest efficiency as a physiologic machine, and as a corollary thereto this end should be sought, when possible, by the use of non-medicinal agents. Change of "scene and air" often works obvious wonders for the good of a debilitated mind and body. Their mode of action is well-nigh mysterious and beyond our present understanding, but we are justified in believing that it is only temporary limitations of knowledge

which preclude our writing at present definite climatic prescriptions, as we do prescriptions for the administration of drugs or baths.

A scientific knowledge of climate in its relation to health is founded upon an understanding of the physiologic effects of the physical factors of climate. In the definite study of the problem each climatic variable, such as density of air, humidity, etc., must be investigated separately; but the results from the solution of these comparatively simple problems cannot be mathematically integrated so as to give trustworthy conclusions as to the effect of their combination in actual climates, any more than the indispensable data from the physiologic laboratories can be mathematically applied in the treatment of disease. Much of the reproach of climatologic teaching has come from attempts at deductive reasoning from these simple data. In short, climatic factors must be studied as to their physiologic influence in detail, and the results thus gained may be used to verify the findings of clinical experience and to suggest directions for the climatic treatment of disease.

THE NATURE OF CLIMATE AND THE PHYSICAL FACTORS BY WHICH IT IS DETERMINED

Climate is the combined result of all natural physical conditions found in any place, especially with regard to its effect upon life. **Meteorology** treats of the physical elements of climate and their laws without regard to life. **Weather** denotes the temporary combination of meteorologic conditions as contrasted with the general average which determines climate. The physical factors that are known to be associated in the production of climate are: (1) Soil; (2) air; (3) water; (4) temperature; (5) light; and (6) electricity. The effect of the combination of these elements upon the climate of any place is determined, in general, by latitude, altitude, and distance from the sea.

Soil is important in its relation to climate as regards its capacity to absorb and hold moisture; its susceptibility to drainage; its porosity or air capacity; its ability to absorb, retain, reflect, and radiate heat; its fertility as influencing vegetation; and its configuration and color. Soils may be divided broadly into three classes, according as they are composed chiefly of sand, of clay, or of loam, the latter being a mixture of the first two, together with organic detritus. Sandy soil is primarily characterized by the readiness with which water percolates through it. It is, therefore, provided the ground-water is at a sufficient depth, a specially dry soil. The dip of the "hard pan" holding the ground-water has an important relation to the drainage of the soil. Sand is also a poor conductor of heat; the sun's rays warm the upper layer of sand, the heat of which is again radiated into the air, rather than diffused throughout the soil. At night, also, the sandy soil loses its heat by radiation much more completely than a soil of clay or loam, so that the extremes of heat and cold by day and night are considerably greater on a soil of sand than on one of clay or loam. The usual dryness of the air over a sandy surface accentuates these

differences of temperature. At night the ground loses its heat by radiation and becomes colder than the air. When there is no wind, the air in contact with the cold surface becomes chilled and denser, and where the surface is uneven, flows downward, to settle in the lowest position.[1] Under such conditions the bottoms of the valleys are colder than the surrounding hills, and mists are often seen confined to the hollows.

Clay holds water tenaciously, and forms, where there is precipitation, a damp soil. H. I. Bowditch long ago showed that tuberculosis flourished in excess where the ground was damp. Such soil conducts heat well and does not become so hot by day or cold at night at the surface as one of sand.[2]

The water content of a soil is a matter of the greatest hygienic importance. Damp ground is probably not only a predisposing factor in the development of tuberculosis, but of rheumatic and catarrhal affections as well. Accumulations of fresh water form breeding-places for pathogenic mosquitos, and the increased salubrity of places, which has long been known to follow thorough drainage, is easily understood in the light of recent views on etiology.

According to Fodor,[3] sandy soil oxidizes organic matter better than the other varieties, and therefore tends more completely to self purification. Soil, he says, is the most extensive and commonest source of the infectious admixtures of air and water. The older views of etiology attributed to the soil the power to generate the miasms of malaria and other "paludal" diseases. As we now know that it is no essential property of soil to give birth to such disorders, there is good reason to suspect that further research will similarly explain the apparent relations of soil to rheumatism and other affections.

Soil has a peculiar bearing on climate from its capacity to support plant life. Earth penetrated by the roots of trees and plants has great power to absorb and hold water. The floods which annually turn so many streams into devastating torrents are said to be largely aggravated by denudation of the forests of the drainage areas. The ground covered by vegetation is shielded from the direct rays of the sun, and its temperature does not rise so high as when it is bare. Moreover, foliage absorbs to a great degree the direct heat of the sun. Heat radiated from the ground is reflected back by the overhanging leaves, so that the surface does not become so cold at night. But the most striking climatic modification introduced by plant life concerns the humidity of the air. Plants absorb water by their roots, chiefly, and give it up in the form of vapor by evaporation from their leaves. The cooling influence of vegetation is, roughly, proportional to this evaporation, which in turn keeps step with the intensity of solar heat. The moisture thus added to the air must form a considerable proportion of the natural humidity. The popular belief that forests cause an increase of the rainfall of a locality is probably well founded. The influence of vegetation, especially of forests, is to mitigate the heat of summer and the cold of winter, to render the days cooler and the

nights warmer. Especially useful are trees in the neighborhood of a dwelling when they are so situated as to be interposed in the path of the winter wind, or as screens to the direct rays of the summer sun.

Pine forests, and the coniferæ in general, have long been held in high esteem, and probably with reason, as conducive to the salubrity of the places in which they are found. They are said to increase the ozone content of the air and thus enhance its antiseptic properties.

The effect upon climate of *configuration of the soil* can be but briefly referred to here. The relative distribution of land and water determines the most fundamental features of climate. Elevation of the land above sea-level, especially in the form of mountain chains, introduces some wholly new meteorologic conditions which will be discussed later on.

The *color* of the soil determines largely its behavior toward heat. The darker the ground, the more readily does it absorb and radiate heat. On the other hand, the reflection of radiant energy is more complete the nearer white the color of the surface. The reactions of the soil to the heat reaching it from the sun form some of the most important phenomena of climatology.

Air.—*Chemical Composition of the Atmosphere.*—Air is a mixture containing, in 100 volumes, approximately: oxygen, 20.96; nitrogen, 79; carbonic acid, 0.04. Watery vapor is always present, but in very variable amount. Traces of ammonia and of ozone have been found. Argon, metargon, krypton, and neon are other gases which have recently been described as existing in the atmosphere in very small proportions. Suspended in the air is a very variable amount of impurity, chiefly in the form of dust, derived from the earth and from living bodies. Nitrogen and argon are supposed to be physiologically indifferent; oxygen sustains life, and carbonic acid is certainly a poison for animals, though it may also have a conservative value.

Effects of Ill Ventilation.—Angus Smith[4] found that the proportion of oxygen undergoes a slight variation, being larger in open than in confined and inhabited spaces. The proportion of carbonic acid in the air of closed spaces is subject to wide variations, dependent on the condition of social life. A man inhales at each respiration only about 4 parts of carbonic acid in 10,000 of air, but he exhales 4 parts in 100. The observations of Angus Smith and of Pettenkofer have shown that the air of crowded school-rooms, court-rooms, or theaters may contain as much as from 20 to 58 parts per 10,000 of carbonic acid.

It was long taught that the poisonous properties of the exhaled breath were due less to the CO_2 content than to the organic matter contained. Later researches have not supported this contention,[5] but, nevertheless, clinical observation makes it apparent that there is a toxicity in the air of ill-ventilated, inhabited rooms that operates surely, though slowly, to the detriment of the vital organism. The bearing of this fact in medical climatology is evident by reason of the tendency of many invalids to remain housed within doors after traveling thousands of miles in search of a climate to restore health.

In a valuable paper, W. B. James* dwells upon the therapeutics of ventilation and quotes the results of observations made by Heyman, Paul, and Ercklentz, who, under the direction of Flügge, conducted an elaborate series of experiments upon men and animals, together with extensive chemical tests, and concluded that "anthropotoxins have no existence. They find that the deleterious effects of close atmospheres consist not in the carbon dioxid, but in the elevated temperature, humidity, and absence of air-currents. Paul placed men in small, close chambers until the atmosphere became very impure, but kept the air in active motion by fans, and found that no symptoms were developed. He then placed them in a similar environment, but with the air still, and had them breathe pure fresh air through tubes. Here the regular symptoms of bad ventilation occurred, but were dissipated when the same air was put in active motion. Flügge concludes that the sensation of well-being experienced with good ventilation is due to abstraction of heat from the body through the evaporation of moisture from the surfaces, and that the removal of expired air plays a relatively unimportant part.

"Hence he concludes that the features to be sought after in the atmosphere are coolness, dryness, and active motion. He considers the CO_2 content relatively unimportant. Rubner finds that it takes but slight motion of the air to markedly increase heat loss."

Ventilation approaches perfection in proportion as the composition of the air indoors resembles that outside. Howell† quotes from Bergey the following data, representing the air-space and air renewal considered advisable under different conditions of indoor life:

	Amount of Ventilation per Hour per Person in Cubic Meters.	Cubic Space per Person in Cubic Meters.
Hospitals	60–100	30 –50
Prisons	50	25
Factories	60–100	30 –50
Barracks	30– 50	15 –25
Theaters	40– 50	20 –25
Halls and assembly-rooms	30– 60	15 –30
Schools	15– 20	7.5–10
Class-rooms for adults	25– 30	12 –15

"The amount of cubic space is based, it will be noted, upon the supposition that the air is completely renewed by ventilation during the course of an hour."

Dust.—Of inestimable importance to health is the character of air with reference to the suspension of foreign solid matters in it. Pasteur showed that the air over glaciers is free from suspended matters. Tyndall[6] demonstrated that "dust" gradually settles from air at rest, and that, in inhabited places, a large part of this dust is of organic material. Bacterial organisms and the pollen of plants are

* Environment in Therapeutics from the Standpoint of Physiology, Amer. Jour. Med. Sci., November, 1906.

† Howell, Text-book of Physiology, 1907.

practically universally distributed in the air of settled communities, and the dissemination of many diseases is due to this source. Inorganic matter in a state of fine division inhaled with the air may penetrate the bronchial mucous membrane, and, being retained in the lung, produce an irritative increase of fibrous tissue in the lung known as pneumonokoniosis, a disorder prevalent among workers exposed to a dust-laden air, such as coal-miners, stone-cutters, etc. This "miner's consumption," or non-bacillary fibrosis, is very apt to have implanted upon it true tuberculosis, due to infection with tubercle bacilli, and the combination proves a very fatal disorder.

Wind.—The character of the soil has much to do with the amount of dust in the air above it, and the bacterial flora of the ground with its infectiveness. Rain and snow have been shown to carry down the impurities of the air. Wind is probably both the most important purifier and the most culpable agent of pollution of the atmosphere. Air-currents descending from great altitudes must themselves be relatively free from dust, and bear along with them the débris suspended above the earth; but when these currents scrape the surface of the ground, they may be transformed at once from refreshing zephyrs into the motive power of strangling dust-clouds.

The meteorologic cause of wind or air in motion does not concern us specifically; suffice it to say that, in general, it arises from differences of atmospheric pressure brought about by unequal heating of adjoining areas. Though apparently the most erratic of meteorologic functions, wind is perfectly uniform in direction, force, and temperature, with definite conditions of formation. A simple example of the orderliness of wind is seen in the land and sea-breezes marking day and night on the sea-coast. Hann[7] writes: "During the morning, the land warms more rapidly than the water, and the warmed air over the land expands upward; or, to put it in another way, the pressure aloft rises over the land more than it does over the water. Therefore the air aloft over the land begins to flow off toward the sea, and the pressure rises over the sea, while it falls over the land. Hence it follows that a lower current of air is set up, flowing from the sea toward the land. This is the sea-breeze. At night the conditions are reversed. The land cools more rapidly than the water. The cooling of the land involves a decrease of the pressure aloft over the land, and with it an inflow aloft of warmer air from the ocean. Consequently, the surface pressure over the land must increase, and that over the sea must decrease. Thus, there results a current of air from the land out to sea, and this is the land breeze. In the morning and evening, between these times of changing winds, there is equilibrium of pressure and a calm prevails."

Winds are cold or warm, dry or moist. They usually have a prevailing direction in any definite place. In temperate zones the wind is the principal factor controlling the weather conditions.* A sea-breeze penetrating far inland may quickly turn dry and clear into

*Cf. Dr. Hann, p. 70

damp and cloudy weather, accompanied by a rise of temperature in winter and a fall in summer. The contrary conditions are brought about when the wind blows for some time over broad continental tracts. When the water-laden wind from the sea strikes a mountain-chain, it flows up the slope, and its moisture is apt to be condensed by the cold of the high altitudes. Thus a wet wind may at once be turned into a very dry breeze, warmed by the freed latent heat of its moisture. The monthly movement of the wind, or the total distance traveled by the air at any point, may be represented by a continuous gentle motion of the air or by alternate periods of calm and tempest.

All the meteorologic features of wind are of extraordinary hygienic and climatologic importance. The skin is the chief avenue for the loss of heat from the body, and the wind, aside from its intrinsic temperature, affects the temperature sense of the body by accelerating the evaporation of moisture from the skin and removing the layer of warmed air in contact with the surface. In choosing health stations where invalids must spend much time in the open air the importance of selecting locations sheltered from the prevailing winds is well known. It is difficult to adjust the resting body to the refrigerating effect of wind, and man has well-founded, instinctive aversion to a "draft" striking an exposed part of the body. Broadly speaking, the statement of Solly[8] is correct, that wind makes a bad climate worse and a good one better.

Humidity.—The atmosphere always contains an amount of water mixed with it in the form of invisible vapor. At certain degrees of saturation the vapor is condensed in the minute droplets forming fog or cloud, or precipitated as water in the form of rain or dew. The humidity of the air owes its origin to evaporation from moist land, bodies of water, and the foliage of plants. The capacity of air to hold insensible watery vapor increases with the temperature. The weight of vapor in a given volume of air determines the *absolute humidity* of the latter. The percentage of vapor present in the air to the total weight necessary to complete saturation is known as the *relative humidity* of the air. The absolute humidity of the air is greatest in the neighborhood of bodies of water and over land clothed with vegetation. It diminishes from the equator to the poles, and, in general, with altitude above the earth. It is greater in summer than in winter, and at midday than in the morning.

Relative humidity of the air is least in the heat of the day and greatest in the morning, when the sun's rays have evaporated the moisture of the surface and before it has had time to be widely diffused upward. At night the ground, cooling by radiation, lowers the temperature of the incumbent air until the contained vapor is condensed as *dew;* this critical temperature is the *dew-point*, the thermometric degree of which is, of course, higher the greater the absolute humidity. From complete saturation of the lowest layer of air at the dew-point the relative humidity decreases as observations are taken further from the surface. Dew is not deposited in cloudy weather, for clouds

reflect the heat radiated from the earth and prevent the fall of temperature on the surface. The same principle is made use of in the protection of delicate growing plants by the horticulturist who wards off the chill of the night air by covering the plants with some heat-reflecting envelop. Winds may also prevent the deposit of dew by replacing the cold with warm layers of air.

A cubic foot of air at —0° F., when saturated with vapor, can hold only 0.54 grain of water. Its absolute and relative humidity are then each 100 per cent. When the temperature of the air is raised to 80° F., 10.95 grains of water must be added to a cubic foot of air to saturate it. The 0.54 grain of water which at zero gave a relative humidity of 100 per cent., would, in the same volume of air at 80°, give a relative humidity of only about 4.9 per cent.

In general, it may be said, as the temperature rises the absolute humidity increases, because the air takes up more water, but the relative humidity decreases because with rising temperature the increase in capacity ordinarily outruns the rate of evaporation. With falling temperature, conversely, there is increase of relative humidity without marked change of absolute humidity until cold causes precipitation of moisture. Thus, we see that both absolute and relative humidity are dependent upon the temperature. On the other hand, temperature is profoundly affected by the amount of moisture in the air. This depends upon the fact that water has extraordinary capacity for absorbing heat. The air itself is nearly diathermanous; that is, pure dry air transmits without absorption nearly the whole of the radiant energy directed to the earth, the carbonic acid alone having a considerable capacity for absorbing heat. Conversely, in dry air radiation from the earth is unimpeded. Consequently, in dry climates the ground and bodies upon it become very hot in the day-time when exposed to the sun's rays, and correspondingly cold at night. In such places, too, there is great difference between the temperatures in the sun and the shade. Observation has shown that, when the quantity of vapor in the air is great or when relative humidity is high, the temperature falls but little at night; and under the same conditions, even when the sky is clear, the temperature rises but slowly in the day-time. In fact, it has been shown that watery vapor is much less easily penetrated by the invisible rays of heat radiated from the earth than by the luminous rays direct from the sun. Moisture in the air, accordingly, leads to equability of temperature, while absence of moisture is marked by rapid alternation in extremes of heat and cold.

In applying these meteorologic data to the study of climatology, it must be remembered that the physical factors of climate act upon a physiologic mechanism which is not inert, but whose reactions determine the influence upon the body of its environment. Lack of moisture in the air leads to more ready evaporation from the skin, which, therefore, tends to become dry. But skin moisture is *sweat* which is produced by the secretory activity of certain glands. Observations seem to be wanting as to the relative activity of the skin

in dry and in moist climates; though the ratio of insensible to sensible perspiration is relatively much greater in the former, it seems probable that the total glandular activity of the skin, temperature conditions being the same, is greater in the latter. The air exhaled being, according to physiologic observations, nearly saturated with watery vapor at its own temperature, it is obvious that the loss of water from the respiratory mucous membrane is inverse to the absolute humidity of the surrounding air; of the absolute humidity, because the air exhaled at different seasons is brought approximately to the same temperature. The probable acceleration of transpiration from the lungs, the drying of the skin and of the nasal mucous membrane in dry climates, are undoubtedly of great, though unmeasured, importance as regards not only metabolism and secretory activity in general, but also as introducing peripheral nerve stimulation, which must have profound physiologic influence.

That climates may be physiologically "stimulating" or "sedative," excite "nervousness" or induce "depression," is well attested by clinical experience. While all meteorologic factors have influence on the vital reactions, it seems probable that the content of watery vapor in the air is directly or indirectly the most important element in modifying the mental, if not the general, physiologic relations of climate. This matter will be referred to later in discussing the distribution of electric tension.

The bearing of the foregoing statements upon house hygiene, at least in dry climates, is obviously important. In inhabited rooms, especially those warmed by hot-air furnaces, the winter air, with its low absolute humidity, is turned into summer air with a very low relative humidity and a drying power which must exercise a very irritating effect on the respiratory membranes and unduly excite the sensory nerves. Means should be adopted artificially to moisten such air before it is breathed. Dampness and dryness are relative and physiologic terms indicative of sensations determined by the loss of water from the surface of the body. According to the rate of evaporation from the skin or the retention of moisture on it, the air may pass, according to our sensations, through every gradation from "very dry," to "very damp." As the living body is surrounded by a halo of air, warmed and moistened by physiologic activity, a breeze which removes this layer would commonly make the air seem cooler and dryer. Again, coolness itself, especially if produced by a breeze, is apt to give us the sensation of dampness, since our judgment of "wetness" on touching a surface is largely founded on the temperature sensation following evaporation of water from the skin.

The influence of temperature has also important bearing on sensations arising from the water content of the air. According to Solly,[8] "On an ordinary sunny day in winter, with the shade-temperature at noon at 40°, we should consider under 70 per cent. of relative humidity as 'very dry'; from 70 to 80 per cent., 'dry'; from 80 to 90 per cent., 'moist'; and above 90 per cent., 'very moist.' . . . .

On the other hand, on a dry day in summer, when the shade-temperature at noon is 70° F., we find less than 30 per cent. of relative humidity at that temperature is 'very dry'; from 30 to 40 per cent. is 'dry'; from 40 to 50 per cent. is 'medium'; from 50 to 70 per cent. is 'moist'; and over 70 per cent. is 'very moist.'"

Hann[7] writes: "When we describe air as being damp or dry, we are usually speaking quite unconsciously of the relative humidity. The air is moist in our climate (Vienna) in winter, notwithstanding the small amount of watery vapor which it then contains; while the air is dry in summer, though it then contains two or three times as much vapor as in winter."

While moisture in the air is the great conservator of equability of temperature, at once shielding the earth from the sun's rays and lessening the loss of heat from the soil by radiation, its physiologic influence is toward the production of extremes of sensation. The principal avenue for the loss of heat from the body is through the evaporation of perspiration. This evaporation is impeded in proportion as the relative humidity of the air is raised, and consequently the oppressiveness of a rising temperature is much more marked in a moist than in a dry air. Again, moisture in the air, when the temperature is low, abstracts the heat of the body by conduction, so that the cold of a moist air seems much more intense and penetrating than that of a similar thermometer registration in dry air. The water content of the air, especially the relative humidity, has probably intimate relations to certain disease processes, as those of phthisis, rheumatism, etc., but whether the influence is essential or due to factors associated with moisture cannot at present be definitely determined.

Temperature.—Both from the physical and physiologic points of view temperature is probably the most important factor determining climate. Temperature decreases from the equator to the poles because the sun's rays slant at a progressively greater angle with higher latitudes, so that the same amount of heat is distributed over greater surface. Temperature also diminishes with elevation above sea-level in the proportion, approximately, of one degree for every 300 feet ascended. The reason for the decrease of temperature with altitude depends upon the relations of the atmosphere to the absorption of solar energy. The shortest waves coming from the sun are largely scattered in the upper atmosphere, giving the blue color of the sky, but the longer rays penetrate toward the surface, being absorbed to a greater or less extent by the watery vapors and impurities most abundant in the lower layers. The invisible rays of long wave length which are radiated back from the warmed earth are much more completely absorbed by the vapor of the air than are the shorter waves direct from the sun. Therefore the air near the surface of the ground is a reservoir of solar heat. The conditions for this retention progressively diminish as we ascend above the surface of the plain, and the physical consequence is increased intensity of direct solar radiation and diminished air temperature.[7]

Climates are equable or variable according as their temperatures depart slightly or greatly from the mean. As moisture is the greatest equalizer of temperature, equability decreases, in general, in any latitude as we recede from the sea and from areas of vegetation. At night the source of heat is radiation from the earth; the resulting air temperature being determined by the amount of heat absorbed by the ground during the day, the quality of the soil, and the amount of cloud and moisture in the air. In the day-time shade temperature is determined by radiation and reflection of heat from the soil, from the air, and from surrounding objects. In the absence of moisture this heat would be mostly dissipated into space, and the shade-temperature would be very low as compared with that determined by a thermometer placed directly in the sunlight. But in proportion as the humidity of the air increases, the radiant energy of the sun is moderated by absorption on the part of the moisture in the air, while, at the same time, the humid air acts as a source of heat in the shade. It, therefore, follows that the difference between temperatures taken simultaneously in the sun and the shade is more or less closely inversely proportional to the humidity of the air, the sun heat being lessened and shade heat increased with increase of moisture.

The physiologic relations of temperature are of profound climatologic importance. Warm-blooded animals retain in health a practically uniform body heat under an extraordinary range of external temperature. Blagden and Fordyce bore the temperature of an oven heated to 260° F., with a rise of 2½° body-temperature, as long as the air remained dry and sweat flowed freely. Arctic explorers record temperatures as low as 70° F. below zero as being borne without injury, a range, in the two cases, of 330° F. It is admitted that this wonderful temperature regulation of the body is the resultant of the interaction of the mechanisms of heat-production and heat-dissipation. Catabolism is increased with cold, and vice versâ. To supply material for heat-production there is proportional to the cold an increase in the ingestion of calorific food, entailing a corresponding increase of activity on the part of the digestive, assimilating, and excreting mechanisms. When the external temperature is raised much above that of the body, the physiologic mechanisms change the direction of their activity and intensity of metabolism. In other words, combustion is decreased, the sudoriparous glands become active, the blood-stream is largely diverted from the interior to the surface, and the nervous system works on a lower kinetic plane.

On *a priori* grounds we might expect to find that all physiologic processes, especially the glandular, muscular, and nervous, would be accelerated in some definite ratio, with increasing distance from the equator. It would also seem probable that the resistance of the body to infections would be increased under these climatic conditions, which excite the physiologic mechanism to the greatest production of energy. On the other hand, in the class of organic disorders or functional weakness not directly dependent on infection,

such as heart disease, senility, etc., it might be expected that climatic conditions would do good in proportion as they stimulated the body to its maximum power of compensation, but would be disastrous in proportion as they throw upon the weakened organs a strain to which the body as a whole cannot efficiently react. As a matter of fact, the statistical study of disease shows that mortality and morbidity rates increase fairly steadily from the arctic to the torrid zone.

But, as Colonel Havard[9] has pointed out, the excess of mortality in the tropics is due to infections which, for the most part, are completely amenable to hygienic control. Colonel Havard writes: "When we (the United States military forces) occupied Cuba, in 1898, we found that the mortality of Havana, for the previous ten years, had been 36 per 1000. Ordinary hygienic measures were at once applied and enforced, with the result that the mortality fell to 24 in 1900, and to 21.20 in 1902, remaining about the same in 1903 under the Cuban Republic." As examples of the efficiency of hygienic supervision he states: "Rome and Madrid are nearly on the same latitude, but the former has a mortality of 18, and the latter of 33 per 1000. Christiania and St. Petersburg are both on the 60° of latitude; the former has a mortality of 12 to 14, and the latter of 24 to 25 per 1000."

Temperature conditions that may only rouse to healthy activity the compensatory powers of some persons prove fatal to those who cannot adequately react to them. Thus, as quoted by Weber and Foster from the Registrar General of Great Britain: "In the last quarter of 1878, including two very cold months, the mortality of people above sixty was 24 per cent. higher than in 1877, when the same period was characterized by mild weather. The rate of increase among people below sixty was only 8 per cent."[10] The problem of estimating the real effect of cold weather on the increase of disease is, of course, greatly complicated by the fact that weak people are prone to remain closely housed in "bad weather," under conditions which themselves reduce the resistance powers of the body.

In comparing the temperatures of different places it is customary to consider the average of three or four observations taken at different parts of the day. On the whole, the mean temperature decreases as latitude increases, but it is obvious that, of two places with the same mean temperature, one may have very hot days, followed by correspondingly cold nights, while in the other location the temperature may scarcely vary at all. The former condition is characteristic of the temperature scale at inland situations, and the latter of marine climates. Not only are the daily and monthly fluctuations of temperature much greater inland than on the sea, but the extremes of mean temperature are greater on continents than on the ocean; the mean temperature at the equator being higher, and that near the pole lower, in the one case than in the other.

While mere meteorologic observations are capable of showing accurately the physical values of weather changes, they are very in-

adequate to express the characters of climate as these impress the living organism. All known meteorologic factors, and probably others we cannot reckon with, operate simultaneously upon our sensory mechanisms. The psychic and physiologic resultant represents their combined action complicated with physiologic reaction. For example, the ordinary thermometer measures the temperature of the air, and it might be supposed that our sensations of temperature would vary parallel with the changes of the instrument. As a matter of fact, however, we find that shade-temperature alone is a very poor indicator on which to base an estimate of *temperature sensation.* The moisture in the air is a variable which determines to a very considerable extent the intensity of our sensations of heat and cold. Heat is lost from the body through the following channels, and, roughly estimated, in the following proportions:

		Per Cent.	
Skin:[11]	Evaporation of water	15.0	80.0
	Radiation	30.0	
	Conduction (and convection)	35.0	
Lungs:	Evaporation of water	15.0	17.5
	Heating the expired air	2.5	
	Heating the excreta		2.5
			100.0

The relative humidity of the air is a most important factor influencing the evaporation of water and the loss of heat by conduction from the surface of the body. A shade-temperature of 80°, with relative humidity of 80 per cent., would be felt as oppressively hot. The same air-temperature with relative humidity at 60 per cent. would seem quite comfortable. In the first case, a breeze striking the body accelerates evaporation from the surface and removes the layer of heated air about it, and gives a sense of delicious coolness. Conversely, when the air-temperature drops much below that of the body, the abstraction of heat by conduction from the surface increases with the humidity of the air, and a breeze, by accelerating this process, gives a sense of penetrating chill. The absorption and radiation of heat by the body are largely regulated by the clothing. Artificial covering is usually designed to protect the person from loss of heat, but there are conditions, as recounted by Mr. Kennan, from his experience in a summer journey on the steppes of Asia, in which, to protect the body from the overpowering heat, it may be necessary to wrap one's self in blankets.

It was the great merit of Professor M. W. Harrington,[12] former chief of the United States Weather Bureau, to have first placed in a clear light certain relations of temperature viewed from the physiologic, as contrasted with the physical, standpoint; though, as Phillips points out in his excellent essay on the subject, the problem is much more complex than might be supposed from Harrington's treatment of it.[13] Temperature as *felt* this author described as "sensible temperature," and the physical counterpart of such sensations is found

less accurately in the records of the dry-bulb than in those of the wet-bulb thermometer. The isotherms determined by these two instruments depart widely from each other. Major W. A. Glassford[14] found that the mean air-temperature at 3 P. M. for July at Sante Fé, New Mexico, was 83.1° F.; at the same time the temperature recorded by the wet-bulb thermometer was 61.4° F. That is, the temperature as *felt* at Santa Fé, N. M., was essentially the same as that felt by people at Winnipeg and Montreal, about 980 and 680 miles further north, respectively. Similarly, in winter the sensible temperature of any given locality in the dry region along the eastern Rocky Mountain slope is apt to correspond to wet-bulb readings taken in moister air very much further south. Finally, it is a matter of common knowledge that high mean temperatures, especially in humid air, such as prevail in the tropics, has a debilitating effect on nervous energy. It may be surmised from human history that what we call "bad" climates include the physical elements which stimulate the physiologic powers to their highest efficiency, and that the best climate for the making of a hardy race is one in which meteorologic variability awakens the maximum physiologic reaction, while at the same time meteorologic extremes are not sufficiently intense to overpower the resistance of the average constitution.

In his admirable work on Climatic Treatment, W. R. Huggard has presented an instructive view of the physiologic responses of the body to climatic influences.

Light.—Dr. Hann points out* that, though we commonly describe the radiant energy of the sun as being composed of heat, light, and chemical rays, these properties depend wholly on the qualities of the bodies insolated. The climatologic relations of light have to do wholly with its effects on living organisms, the rays themselves differing only in wave length and rate of vibration. Light is essential to animal and to vegetable life. The intensity of light is inverse to the absorption by the atmosphere, though the diffuse light is largely due to reflections from minute particles of water and dust suspended in this medium. Reflection from the earth, water, and bodies upon the surface is a very important source of light. Though physiologic experiment has proved that light can act as a direct stimulus to protoplasm, it is no doubt true that the vast importance of this agent to animal life is exerted indirectly through the higher nerve-centers. The clear, sun-lit sky and the cloud-overcast heavens have become established in literary imagery to stand for opposite mental states of cheerfulness and depression. For the well-being of those who are in good physical health the absence of sunshine when it should be present may even work as a stimulus to the development of stronger mental natures, but to the idle stranger in a strange land, or to the invalid who falls so readily a prey to mental depression, the failure of the sun to make his daily appearance is a calamity. In health resorts, therefore, the number of hours of sunshine forms one

* *Loc. cit.*, p. 34.

of the most important elements to be considered. On the other hand, Major C. E. Woodruff, U. S. A.,* insists that excessive insolation is a fruitful source of nervous derangement, such as neurasthenia and its complications, especially in persons of blond complexion.

While light is undoubtedly a psychic and physiologic stimulant, its effects in the tropics, whence Woodruff's conclusions were chiefly drawn, are complicated by the powerful influences of excessive heat and humidity. In practical therapeutics it is usually safe to trust to the patient's sense of well-being as a guide to the amount of illumination best suited to his case. The cleansing power of sun and air, probably due to oxidation of organic matter under the influence of light, has been familiar from the earliest times.

Since the announcement of Koch, in 1890, that direct sunlight kills tubercle bacilli in from a few minutes to several hours, according to the thickness of the layer in which they are exposed, and that diffuse daylight accomplishes the same result within five days, sunlight has been generally regarded as a most important natural germicide. That the bactericidal effect of sunlight under ordinary conditions was overestimated by Koch has been shown especially by Mitchell and Crouch,[15] who, working in Denver, showed that in tuberculous sputa spread on sand the tubercle bacilli were still frequently infective after thirty-five hours' exposure to direct sunlight.

Atmospheric Pressure and Altitude.—As already stated, wind owes its origin primarily to fluctuations of barometric pressure brought about by unequal heating of the earth's surface. At sea-level the average pressure of the atmosphere sustains a column of mercury about 30 inches (about 760 mm.) high. As we ascend above the surface there is progressive diminution of atmospheric pressure, approximately at the rate of 6.94 mm. for every 100 meters elevation.

The physical factors of climate and their relations to life are extensively modified by altitude. As has already been pointed out, the absorption of solar energy by the atmosphere is almost wholly due to watery vapor, and impurities with moisture condensed on them, suspended in it. These elements, especially the latter, diminish in proportion as we ascend above the surface, with the physical consequence that solar insolation progressively increases and air-temperature decreases in intensity with altitude. There is, accordingly, great difference between the temperatures registered by a thermometer with blackened bulb suspended *in vacuo* under the sun's rays and by an ordinary instrument hung in the shade. The boiling-point of water diminishes and evaporation increases with altitude, irrespective of temperature and relative humidity; accordingly, the registration of the wet-bulb is correspondingly lower than that of the dry-bulb thermometer. The relation of these facts to "sensible" as compared with "air" temperatures has already been pointed out.

Physiologic Influence of Altitude.—The respiratory processes demand a certain oxygen pressure in the air. It is an accepted fact that

* The Effects of Tropic Light on White Men, 1905, New York and London.

absorption of oxygen by the blood is determined by the partial pressure of oxygen in the air, without regard to the pressure of nitrogen. Thus, at sea-level, with an atmospheric pressure of 760 mm. Hg, the oxygen pressure is about 152 mm. Experiments upon the arterial blood of the cow and dog show that when the oxygen pressure falls to 60 mm. Hg, the gas ceases to be absorbed and begins to be given off. The oxygen tension in the atmosphere reaches 60 mm. when the total barometric pressure falls to 300 mm., and this corresponds to an altitude of about 5500 meters, or 17,000 feet.[16] This, or a somewhat lower altitude, may be regarded as the physiologically critical elevation.

But most of the vital effects due to altitude are felt far below this level, and cannot be due to insufficient oxygen supply to the lungs. The experiments of Bert[17] lead to somewhat different conclusions. This author drew the arterial blood from dogs confined in a chamber in which the air-pressure could be lowered to any desired degree. The amount of oxygen and carbonic acid in the blood decreased fairly steadily with fall of pressure, though the diminution was most rapid when the experimental pressure fell to about half that of the atmosphere.

Tissot,[18] on the other hand, found that in dogs there was no change in the gas contents of the blood until external pressure fell to 480 mm., and also that the total amount of gas in the blood increased with altitude reached by balloons, at least up to 3500 mm. As Foster writes, "The breathlessness which is so marked a feature on these occasions (mountain-climbing) seems due not so much to the fact that the blood which reaches the respiratory nervous centers is deficient in oxygen, as to the fact that the troubled vascular system fails to deliver to those centers the blood in an adequate fashion."

Mountain-climbers describe a peculiar, acute disorder, manifested by disturbance of the cardiac, respiratory, and gastric functions, brought on by ascents. The symptoms, according to G. v. Liebig,[19] appear, on the average, in Europe at an altitude of 3000 meters (9840 feet). With increasing elevation the morbid disturbances usually take place in the following order: the respiration becomes less ample; there is unwonted weakness in the legs; the movements of the heart are greatly accelerated and painfully felt; there are faintness and slight nausea, and, at times, vertigo. Eating is impossible. There supervene drowsiness, confusion, and embarrassed mental activity; swelling of the veins of the face, arms, hands; lividity of the face; severe headache; coldness of the hands and feet; nausea and vomiting; sometimes exudation of blood from mucous membranes of eyelids, nose, gums, and bronchi. With rest in the recumbent position all symptoms abate. Oxygen inhalations are especially effective in restoring the normal condition.

This *mountain sickness*, as it is called, has been a favorite field for scientific speculation, almost every conceivable explanation of its pathology having been offered. The disturbance is referred to here only because it seems probable that the slight disorders, such as

dyspnea on exertion, a feeling of heaviness in the feet, heart palpitation, etc., sometimes complained of by new-comers to an altitude of one mile or more above sea-level are but mild symptoms of the same pathologic series. Little or nothing is heard of *mountain sickness* in its extreme forms in Colorado, where a flourishing city, Leadville, is at an altitude of 10,200 feet, and where thousands of strangers annually ascend on a cog-wheel railroad to the top of Pike's Peak, at an elevation of 14,100 feet.

In the famous balloon ascension of Sivel, Tissandier, and Croce-Spinelli, in which two lost their lives, the barometer registered an extreme elevation of 8600 meters (28,215 feet). The results were complicated by the fact that the observers breathed at times from reservoirs of oxygen.[17]

The blood is capable of absorbing sufficient oxygen for the needs of the body at elevations far beyond those inhabited by man, but the physiologic mechanism is adjusted to work under a limited range of atmospheric pressure, and various disturbances, affecting particularly the vascular apparatus, often result from sudden removal from a lower to a higher altitude. Dyspnea on exertion is the commonest expression of such disturbance.

It is generally admitted that the rates of pulse and respiration are increased for a time after a person removes to a higher elevation, but that the body gradually adjusts itself to the new conditions and the normal rates return. The girth of the chest and its power of expansion increase with the altitude. Gardiner and Hoagland* weighed and measured more than 1000 school-children at Colorado Springs (altitude, 6000 feet), and compared the results with similar data obtained at Chicago and St. Louis (less than 900 feet elevation). They write: "Our comparisons prove not only greater girth of chest and vital capacity in native-born Colorado children as compared to children in St. Louis or Chicago, but we further found that in exactly the same ratio the Colorado children were taller and weighed more." Yet observers agree in the remarkable statement that diminution of atmospheric pressure is accompanied, at least at first, by diminution of vital capacity of the lungs. Paul Bert found that when he remained in a closed chamber in which the pressure was diminished, his vital capacity, measured by the maximum volume of air which can be expelled after a full inspiration, progressively diminished. When the air-pressure was reduced to 420 mm. Hg, his vital capacity was lowered nearly one-half. Mosso found that at up to an altitude of 4560 meters (14,960 feet), pressure 423 mm. Hg, though the vital capacity was diminished, the volume of air breathed in an hour usually, but not always, increased. Somewhat different results were obtained by Hallion and Tissot in ascending to an altitude of 3500 meters (11,482.9 feet).[22] In explanation of the temporary diminution in vital capacity in high altitudes, Kronecker† and Mosso‡

* Trans. Amer. Climatolog. Assoc., vol. xix, 1903.

† Die Bergkrankheit, 1903. ‡ Life of Man on the High Alps (Trans.), 1898.

agree in ascribing it to congestion of the lungs and dilatation of the heart, which they hold are induced by the lowered barometric pressure. On the contrary, Zuntz and his colleagues (see *infra*) attribute the diminished amplitude of lung expansion to the increased volume of gases in the abdominal tract permitted by the lowered surface pressure.

The general facts indicate the truth of Foster's assertion that the physiologic phenomena asserting themselves at moderately high altitudes, say, under 10,000 feet, are due not to insufficiency of oxygen, but to disturbance in the equilibrium of physiologic processes, by which it is appropriated by the tissues.

Blood Changes in High Altitudes.—Practically all observers agree that the numerical estimation of the red blood-corpuscles, both in the lower animals and in man, increases with altitude. Viault found in Peru that, in ascending from sea-level to the altitude of 14,275 feet, after three weeks the red corpuscles had increased from 5,000,000 to 8,000,000 in the cubic millimeter. W. A. Campbell and H. W. Hoagland found that the average red blood count at Colorado Springs (altitude, 6000 feet) was 5,845,000, while after ascending Pike's Peak by railroad (altitude, 14,147 feet) the count rose to 6,292,000, falling to 5,734,500 after the return journey.[23] They also found the peripheral blood-count increased by massage and physical exercise.

Egger[24] found that at Arosa (altitude, 5500 feet) there was, after two weeks, an average increase of 16 per cent. in the red corpuscles, and that the increase was greater in tuberculous than in healthy persons. Later on the percentage of hemoglobin increased to about the same extent. This is the same order in which corpuscles and hemoglobin increase after profuse hemorrhage. He found, in rabbits, that the increase of corpuscles occurred in the blood of the great arteries, as well as of the veins. Therefore, it was concluded that the changed blood-count did not depend upon a change in the vascular distribution of the corpuscles. Also, the relative volume of corpuscles to plasma, as determined by the centrifuge, remained the same at high as at low altitudes, and, therefore, the increased blood-count did not depend upon loss of water from the blood.

J. Gaule[25] found, during a balloon ascent, numbers of nucleated red corpuscles which he took as evidence of an actual increase in the number of erythrocytes. Armand-Delille and Meyer[26] found that rabbits, kept from two to seven weeks at an altitude of 2000 meters, showed no change in the number of blood-corpuscles either in the blood of an ear vein or of the heart. Kemp[27] found an increase of about 400,000 red cells at 9400 feet, and about 1,000,000 at 14,000 feet. There was a variation of about 1,000,000 between forenoon and afternoon. There were characteristic changes in the blood-plates. It seems exceedingly probable that the rapid apparent increase of blood-corpuscles with rising altitude is fictitious, and due to their accumulation in the superficial veins, owing to causes which will be considered later.

That there is a true and permanent high-altitude polycythemia seems definitely settled by the monumental work of Professor Zuntz,

in association with Loewy, Muller, and Caspari.* These physiologists made a prolonged series of observations on Monte Rosa, in the Alps, at an elevation of 14,960 feet. They found that the number of embryonic red cells in the bone-marrow of animals transported to the height was greatly in excess of those in similar creatures examined near sea-level. They also verified the statements that the quantity of hemoglobin was greater, by 20 to 30 per cent., in animals kept on the mountain. These changes do not reach their maximum at once, but proceed gradually, for several weeks.

Gerald B. Webb, of Colorado Springs, maintains that the mononuclear elements of the white blood-cells are independently increased by residence at high altitudes. He and his colleagues believe that this specific lymphocytosis is excited by increased hyperemia of the bone-marrow, and they explain the favorable influence of elevated regions in the treatment of tuberculosis by the view that the mononuclear white cells are the specific antagonists of the tubercle bacilli.†

Blood-pressure in High Altitudes.—The recent awakening of clinical students to the importance of blood-pressure as a vital phenomenon has added but little to our knowledge of the relation of this fundamental function to atmospheric pressure. Potain[28] found that human arterial blood-pressure, determined by an instrument applied to the radial artery, usually progressively increased up to the extreme altitude observed—1255 meters (4117 feet). There was a return toward the normal with descent.

Janeway[29] quotes Crile and also Lazarus and Schirmunski to the effect that arterial blood-pressure rises when external pressure is increased, and vice versâ. Camus[30] measured the arterial blood-pressure of rabbits inclosed in an air-chamber in which the barometric pressure was gradually reduced as low as 200 mm. Hg. The blood-pressure sank parallel with the air-pressure.

With the sphygmomanometer invented by himself, which is said to indicate the diastolic blood-pressure, Mosso estimated his blood-pressure on Monte Rosa, altitude 14,960 feet, and found it to be the same as in Turin.

Gardiner and Hoagland made comparative observations on 22 young men at Colorado Springs, elevation, 6000 feet, and on the summit of Pike's Peak, elevation, 14,130 feet.‡ The blood-pressures were measured by instruments of the Riva Rocci and Janeway designs, and were, therefore, of systolic value. At the lower level the average pulse-rate was 80, the blood-pressure, 126 mm. The men under observation were then transported by railroad to the top of the neighboring mountain, where, after a sojourn of three and a half hours, the average pulse-rate had risen to 99 and the blood-pressure fallen to 118 mm.

* Höhenklima und Bergwanderungen, 1906.

† Webb, Williams, and Basinger, "Artificial Lymphocytosis as a Possible Aid in the Treatment of Tuberculosis," Colorado Medicine, January, 1910.

‡ Trans. Amer. Climatolog. Assoc., vol. xxi, 1905.

Little as is known regarding the relation of altitude to arterial blood-pressure, observations seem to be almost wanting as to its effect upon the scarcely less important function of venous pressure. I have[31] been led to believe, on the evidence of clinical observation made at one mile above sea-level, that the characteristic influence of high altitudes upon the circulation consists, especially in new-comers, in relative massing of the blood in the veins and the right side of the heart. Relative increase of resistance to the flow of blood through the lungs would be followed by such a result, and would explain many of the phenomena of mountain sickness, and incidentally account for the increased blood-count in superficial vessels. Such pulmonary resistance would theoretically lead to abnormally high venous and correspondingly low arterial blood-pressure; some dilatation and compensatory hypertrophy of the right side of the heart would be the natural sequence. The writer has found his venous blood-pressure, estimated by Gaertner's method of noting the height to which the hand must be raised, to cause collapse of its veins, to be higher immediately on his return home, at an elevation of one mile, than at sea-level. After a few days the excess of venous pressure diminished. According to some unpublished observations that I have made at Denver, one mile above sea-level, the outline of cardiac percussion dulness reaches commonly much further to the right than is represented in the received descriptions. On carefully outlining the heart by means of the phonendoscope, Mosso* was convinced that the organ markedly dilates at high elevations. This dilatation is similar to that resulting from strenuous exercise, and, like it, is no doubt temporary. Babcock's well-founded statement that mitral stenosis is the form of heart disease which especially contraindicates residence in high altitudes finds a scientific basis in the postulate that at high elevations venous blood-pressure tends to be relatively increased. The observations of von Liebig[19] and others definitely point to the establishment of unusual resistance to flow of blood through the pulmonary capillaries as one of the mechanical consequences of diminished atmospheric pressure, at least when rapidly accomplished.

Metabolism.—The laying on of proteid matter commonly ceases when adult age is reached. But Zuntz and his colleagues point out that a specific influence of life at moderately high elevations is a stimulation of the assimilation of proteid substance, and this can be increased by judicious exercise. This process is reversed at extreme elevations. Similar augmentation of proteid assimilation is said to be excited by residence at the seashore. It is interesting to note that this improvement of metabolism initiated at high altitudes goes on for a considerable period after return to lower levels.

The physiologic differences between high and low altitudes are greatly accentuated by muscular exercise. The pulse beats faster in doing the same amount of work in proportion to the elevation above the sea, and there is clear evidence that the activity of every function

* *Loc. cit.*

is similarly accelerated. One of the most valuable results of the work of Zuntz is the demonstration of the importance of *training* in fitting the physiologic mechanism to attain the highest machine efficiency. Even vigorous mountain guides, he found, used up much more oxygen, produced more wastes, and suffered much more physical distress in performing a certain amount of mechanical work in the spring after a winter's idleness than in the autumn at the end of a season's climbing. The necessity for training, another term for acclimatization, is peculiarly important in the case of invalids seeking elevated regions for their health. In such resorts the exhilaration induced by the quality of the crisp, dry air, the brightness of the sunshine, the sudden changes in temperature in stepping from sun to shade, often induce the newcomer to make demands on his muscles that they are quite unable to meet without disastrous metabolic friction. Every year the mortuary report of Denver is unnecessarily swelled with data of pulmonary edema and other disorders resulting more or less directly from overexercise in the untrained. It has been found that though at high altitudes the actual consumption of oxygen is greater than on the plains, there is a more or less marked accumulation of suboxidized or fatigue products in the circulation which irritate the nerve-centers and in turn affect metabolism. The production of these substances is greatly augmented by physical exercise, is subject to great individual differences, and is done away with after thorough acclimatization.

The Nervous System.—What has just been said as to the influence of elevated regions in stimulating metabolism, especially with exercise, may be emphasized in considering the nervous functions. No other environment is capable of giving so permanent and exultant a joy of living; but, as a stimulating tonic may in excess prove a deadly poison, so the necessity for the therapeutic regulation of all avenues of physical and psychic excitement, at least in newcomers, becomes accentuated in higher regions.

Electricity is a climatic factor of unknown significance. It is said that the electric condition of the earth is negative to that of the atmosphere, and that the air of inhabited rooms is negative to that outside. When the air is very dry, a few steps across the carpet of a room charge the body with electricity by friction of the feet, so that sparks fly when a metallic conductor is touched. This is a very common occurrence at high altitudes, and partly suggests the popular notion that the nervous influence of climate has much to do with electricity.

ACTUAL CLIMATES AND HEALTH RESORTS

It is not possible to classify climates in a simple way so as to separate into groups all the important physical conditions. On the whole, the division into marine and continental climates, with a subdivision according to altitude, seems most capable of assorting complex meteorologic conditions. The important element of mean temperature depends definitely enough on latitude to be considered a

constant factor. The following climates may be distinguished: (1) *Marine climates*—(a) *Sea climates* and (b) *coast climates.* (2) *Continental climates*—(a) *Lowland climates* and (b) *mountain climates.*

SEA CLIMATES

A sea climate is to be found only in a voyage on the ocean. Purity of air, equability of temperature, and a high degree of humidity are physical characteristics of a sea climate. The daily range of temperature in the shade is said rarely to vary more than 4° or 5° F., and the mean relative humidity is between 74 and 75 per cent. of saturation. Neither extremes of heat nor cold are felt on the water in temperate zones. The vicissitudes of weather are much more important on the water than on the land, for prolonged sea-sickness, or conditions which constrain the passenger to remain below decks, does away with the benefits of a sea voyage or may result in positive harm. The size, situation, and ventilation of the cabin are of the utmost consequence to the health-seeker. The character of the food and the personnel of the ship's roster are of great importance. The benefits of a regular mode of life, freedom from worry, a maximum amount of time spent in a bracing, open air, should be most easily achieved in a sojourn on the sea. Only those who can recover quickly from sea-sickness, who can live a due proportion of the time on deck, and whose digestive functions will respond to the changed conditions of table fare should visit the sea for therapeutic purposes.

An important feature of an ocean voyage is its terminus. The anticipations of new scenes and strange phases of life at the journey's end add much to the interest of the trip. It is important, of course, that the climatic conditions of the ports touched should harmonize with the purposes of the voyage. Other things remaining the same, the season of the year is the most important factor in determining the direction of an ocean journey. In summer an unique trip is said to be that from San Francisco along the western coast of North America to Sitka, Alaska. Any of the North Atlantic routes, particularly if extended to Scandinavian ports or through the Baltic Sea, offer much of interest to the traveler. It is during the winter that ocean travel has its most peculiar charms if the route is chosen so as to take the voyager from some ice-beset port successively through the balm of spring to the warmth of summer. Such a trip is offered those who leave New York in the winter for a visit to the West Indies and points south on the continent. At this day sea voyages to the Mediterranean ports, to subtropical islands, such as the Canaries, Cape Verde, Hawaii, etc.; to South Africa, South America, and Australia, are relatively familiar to the public. The excellent monograph of Weber and Hinsdale[33] leaves little to be desired for those who would make out an itinerary for definite therapeutic purposes.

The characteristic therapeutic effects of a sea voyage may be said to be tonic-sedative. Nervous strain is relaxed, while at the same

time the bracing salt air stimulates appetite and digestion, and the improvement in metabolism usually leads to sound sleep. Unfortunately, on long voyages, and except in the finest vessels, the food is apt to lack variety and to be of a character unsuited to invalids. *Sea voyages are indicated* in most "run-down" conditions and in neurasthenia in its milder forms. In a good sailor a long voyage might be expected to prevent the development of latent tuberculosis. Chronic catarrh of the respiratory and genito-urinary tracts is apt to be benefited, as are chronic rheumatoid pains. On the contrary, patients with advanced tuberculosis or most of the gastro-intestinal disorders, and those who suffer from advanced cardiac or vascular disease, should not be advised to take an ocean voyage.

Small islands combine the advantages of a nearly completely marine climate with those of a life on shore. The Samoan and Hawaiian groups in the Pacific Ocean, and Madeira, the Canaries, and the West Indian Islands in the Atlantic, will be referred to later.

COAST CLIMATES

Coast climates differ from purely marine climates in the alternation of land and sea breezes, and in the accentuation of conditions of temperature and humidity dependent on the meteorologic conditions of the adjacent continental areas, and the proximity and temperature of ocean currents. Sea-coast climates differ very materially from one another as to temperature, humidity and air-movement, according to latitude, the temperature of the water, the direction of prevailing winds, and the outline and topographic features of the neighboring land. Thus, the temperature of the British Isles is far higher than would be expected at their latitude by reason of the influence of the warm "Gulf Stream." The warm "Japan current," the "Kurosiwo," is supposed by some to be largely responsible for the comparatively high temperature on the northwestern coast of the United States. The general characteristics of coast climates are equability of temperature, a nearly constant movement of air, sea breeze by day and land breeze by night, and air which is pure and more or less impregnated with salt spray. The comparatively high humidity and the wind movement accentuate the feeling of cold on the seashore at temperatures which would seem warm in land.

The *physiologic* influence of most coast regions is stimulating. Therefore, for therapeutic purposes, the seashore is to be recommended in debilitated conditions in which the reactive power is still good. Anemic persons, weakly children, especially those with scrofulous constitution, and persons who are "run down" from work or worry or who are convalescing from disease, are favorable cases for sojourn at the seashore. I have seen much benefit derived by children with chronic bronchitis from a sojourn near the sea. Patients with skin diseases and chronic heart troubles, with considerable dilatation, are apt to do poorly on the coast. Sea-bathing requires considerable

reactive power on the part of the bather to give good results, and is very likely to be abused by too long immersion.

Special Island and Coast Climates and Resorts.—Humidity and temperature are the meteorologic factors which chiefly determine the climates of marine resorts. Islands in tropical and subtropical latitudes are, for the most part, beautified by luxuriant vegetation. Their physiologic influence is one of profound restfulness, without positive inertia, though the "sweetness of doing nothing" may become to the sojourner a sufficient reward for the decay of northern energy. The admirable monographs of F. P. Weber and Hinsdale, forming the third volume of Cohen's System of Physiologic Therapeutics, 1901; of Solly, Medical Climatology, 1897; the more condensed essay of H. Weber and M. G. Foster in Allbutt's System of Medicine, vol. i, 1896, second edition, 1905; Huggard's Handbook of Climatic Treatment, 1906; and various brochures in Buck's Reference Handbook of the Medical Sciences, present to English readers so thorough a view of climatic resorts that, in the following pages, I shall only attempt to treat of a few localities as types of varied climatic conditions.

The *Madeira Islands*, situated between 32° and 34° north latitude and 16° and 17° of west longitude, 360 miles west of the coast of Morocco, have long enjoyed a wide reputation, especially in England, as a winter resort. *Funchal*, the principal town, with a population of 20,000, lies on a hillside. The mean relative humidity varies usually from 70 to 74 per cent., though at times it is much less. The mean annual temperature is 65° F., rising to less than 70° in summer, and falling to 61° F. in winter. The highest and lowest temperatures rarely exceed 86° F. by day or 43° F. by night. The sea breeze blows from 9 A. M. to 3 P. M., and the land breeze at night. The mean annual rainfall is 27 inches. The air is moist and relaxing. The Madeiras at one time enjoyed a great reputation as a resort for consumptives, but the experience on which are founded the more recent therapeutic views has condemned the opinion. Patients with irritability and catarrh of the respiratory mucous membrane, and those that need a sedative climate, are said to do well there.

The *Canary Islands* are Spanish possessions, and lie nearly 300 miles south and east of the Madeiras. Their climate is warmer and drier. The island of *Teneriffe* is famous for its peak, which rises 12,000 feet above the sea. *Orotava*, the capital, has an average temperature, for January, of 60° F., and for July, of 73° F. The temperature rarely rises above 82° F. The climate of the city is greatly modified by a layer of cloud enveloping the mountain ridge at an altitude of 3000 to 5000 feet. It tempers the heat of day and remains until dissipated by the south wind springing up in the late afternoon. On the mountain above the cloud-layer the air is very dry, and the extremes of temperature are very great. "Orotava lies in a valley on the north of the island, facing the open Atlantic, and sheltered behind and on two sides by the mountains; its mountains and coast scenery and its vegetation justify Humboldt's opinion that it is 'one of the most

charming spots in the world.'"[33] Various towns in different parts of the Canary group offer a wide range of meteorologic conditions, embracing in some degree the opposite conditions of marine and mountain climates in close association.

That great collection of island groups, the *West Indies*, reaching from about the tenth to the twenty-seventh parallel of north latitude, also presents a series of warm, moist, and equable marine climates. Leaving New York harbor in bleak winter weather, less than four days by steamer brings the traveler to a delightful and tempered summer at *Nassau*, the capital of the *Bahama Islands*, which are British possessions. The island upon which the town is situated is about 5 by 20 miles in extent, and is a mass of coral limestone. The sea-water is phenomenally clear, and the breaking of the surf upon the barrier reef lends a life that is wanting on the peaceful island. Dr. S. A. Fisk[34] writes: "There exists at Nassau a summer climate at mid-winter, an ocean climate on dry land; brilliant sunshine, June air, inducements to living out-of-doors at sea-level. But this same air, while equable in temperature, is hot and it is moist." The mean monthly temperature for winter is 71° F. The average relative humidity for winter is about 83 per cent. Solly writes: "Nassau has warmer winters than Bermuda, the Azores, Madeira, or Teneriffe. The air at Nassau appears to be less moist and muggy than that of Bermuda." Availability of other West Indian islands for health purposes depends chiefly upon local sanitary conditions. In *Porto Rico* these are better controlled since the American occupation, and *Cuba*, since its evacuation by Spain, promises to be a safe and favorite resort for those who would escape the rigors of a northern winter among strange and interesting scenes. *Jamaica*, belonging to the British crown, has lately attracted many who have sought mental relaxation in a tropical winter. The *Bermudas*, climatologically a part of the West Indies, are English possessions. Their towns, like Nassau, are furnished with good hotels, and the winter climate resembles that of Nassau, though it is cooler and somewhat less damp. The islands are distant from New York less than three days by steamer. A voyage of six or seven days southwest from San Francisco on a good steamer brings the traveler to *Honolulu*, a city of 25,000 population, the capital of the Hawaiian or Sandwich Islands. Some of the islands are mountainous. Two volcanic peaks on the largest island of the group, Hawaii, have a height of nearly 14,000 feet. The topographic features of the islands give rise to great differences of temperature and moisture in places which may be close together. In 1903 the rainfall in different districts of the islands varied between 8.19 and 319.8 inches. The average yearly temperature at Honolulu is about 74° F. The yearly range of the monthly averages is less than 8° F. The relative humidity is about 72 per cent., and about 37 inches of rain fall, distributed through two hundred and eleven days of the year. There are localities in the islands offering great advantages as health resorts, but they are as yet incompletely available.

Turning from types of winter to those of summer marine resorts, the seeker after health or pleasure finds off the coast of New England a bewildering collection of charming islands, where the salt air is refreshing, hotel accommodations are good, and facilities for healthful amusements, such as fishing, sailing, and bathing, are ample.

Mount Desert is an island off the coast of Maine, rising more than 1500 feet above the sea. Its town of *Bar Harbor* is a fashionable summer resort. It is said that the mean temperatures are 70° F. for the day and 64° F. for night. Fogs are somewhat frequent. *Martha's Vineyard*, off the southern coast of Massachusetts, combines, like the former, the choice of advantages given by rural, village, or town life. *Cottage City*, its principal town, attracts those who enjoy social without fashionable life by the sea. *Nantucket* is further out in the Atlantic, and more primitive from a social point of view. The mean relative humidity is 81 per cent. The mean monthly temperature for summer is 64° F. The air-movement is constant, and the wind sometimes is high. The air is relatively dry and stimulating. Solly says[8]: "One of the mildest and driest of the sea climates north of St. Augustine (Florida) is found on the south-eastern shore of Nantucket." All these islands are of porous, mostly sandy, soil, and they are reached at least daily in the summertime by steamers from the mainland. In physiologic influence their climate differs from that of tropical islands in the preponderance of the stimulating over the relaxing qualities of the air.

Special coast climates differ in a material way from those of islands in that that they may be enjoyed without the inland invalid having to undergo the rigors of a trip by sea. Different coasts exhibit a surprising diversity as to temperature and equability, as, for instance, the eastern and western borders of North America. The climates of the famous *Mediterranean resorts* owe their character chiefly to the great inland sea, which conserves the temperature of southern Europe. The shallow strait of Gibraltar is said to bar the Mediterranean from the cold polar current, and the warm waters of this sea are the source of the equable and relatively high temperature of the southern coast of Europe. The narrow strip of coast line, one to four miles in breadth, reaching nearly northeast from Toulon in France to Genoa in Italy, known as the *Western Riviera*, and from Genoa southeast to Pisa, the *Eastern Riviera*, has acquired great fame as a resort for pleasure-seekers and invalids. The former is more frequented by English and the latter by German people. The eastern part is somewhat colder and moister in winter than the western. The "season" on the Riviera extends from late autumn until middle spring. The coast, particularly of the western portion, is sheltered more or less from continental influences by mountain ranges. The climatic characters which distinguish the Riviera are comparative dryness, purity of the air, large amount of sunshine, and relatively high winter temperature. The mean temperature of the Western Riviera for the colder half of the year is 51° F., and the mean relative

humidity, 65 to 70 per cent. Peculiar among coast climates is the considerable difference found here between temperatures in the sun and shade; there is a rapid fall of temperature and increase of relative humidity of the air at sunset. Wind and dust form frequent obnoxious features of the coast. The climate is said to be especially adapted to the needs of those suffering from chronic pulmonary tuberculosis, catarrhal conditions of the respiratory organs, and chronic disorders associated with deficient powers of reaction.[33] The extraordinary advantage possessed by the Riviera over most similar resorts consists in the accessibility to the interests and diversions of leisure, civilized life offered by a large number of attractive and cultivated communities. The dangers of such privileges to the invalid, particularly if tuberculous, require unusual watchfulness on the part of the medical adviser.

The Coasts of Great Britain and Ireland.—To people from other lands the striking feature of the climate of the British Isles is the relatively high temperature for the latitude, the mean winter temperature being higher by from 20° to 40° F. than would be expected. The mean annual temperature is about 50° F. for the east coast of Great Britain, and a few degrees higher for the west coast. This peculiarity is attributed to the influence of the surrounding warm waters, and especially to the Gulf Stream, which heats the winter air blowing over the islands (Buchan). The climatic result is a rather humid air, with relatively mild winters and cool summers, and little intensity of solar radiation. The western coast is said to be warm and moist, and the eastern, relatively dry and cold. Good summer resorts, mostly distributed on the eastern coast, are very numerous. The climate, on the whole, is not always agreeable, often dull, and requiring resistance to cold, damp winds and sudden changes; but it is bracing and tonic, and the characteristics of the inhabitants form the best evidence that the physical environment is one to develop strong minds and bodies.

The eastern coast of the United States is provided with many resorts for health and pleasure, those north of New Jersey being frequented exclusively in the summer, and those in Florida only in the winter. The bracing salt air, the fair sanitary arrangements, the easy accessibility, and the interesting social conditions make the northern stations very attractive for summer sojourners. Every grade of social environment can be obtained, from the relatively primitive isolation of Cape Cod, at the end of a narrow strip of land reaching far into the Atlantic, to the fashionable gatherings at Newport and Narragansett Pier. *Atlantic City*, New Jersey, though on an island, is practically a coast resort, being reached directly by train, which makes the trip from New York in about three hours and from Philadelphia in one. The place is phenomenal for its large number of good hotels. The air is said to be drier than that of other places on the coast, though the relative humidity for summer is 83 per cent. of saturation, with a mean temperature of 70° F. The resort is fre-

quented both in winter and summer, great crowds of pleasure-seekers thronging, in the latter season, the famous "boardwalk," which runs for four miles along the ocean edge. The air is bracing and delightful. The temperature is milder than is usual for the latitude. The sea breeze, beginning before noon, blows throughout the day. In the winter it brings the warm air from the ocean.

The oldest American city, *St. Augustine*, is on the eastern coast of Florida, latitude, 29°53′ N. The mean temperature of the winter half year is 61° F. The mean annual rainfall is about 49 inches. The climate is mild, moist, and equable. The population of the town, 5000, is doubled by the influx of visitors in the winter. Most of the charms of a subtropical life are to be found here, the natural resources being developed by business enterprise for the amusement of the sojourner who can pay his way. The Florida resorts have the added advantage of accessibility, without sea voyage, to the great centers of civilization. *Galveston*, Texas (population about 38,000), is situated on an island formed of a strip of sand close to the mainland on the western coast of the Gulf of Mexico. The city is a favorite retreat in winter for people living in the northern inland, and is visited in summer by dwellers farther south. The mean temperature for winter is slightly over 55° F.; the mean annual temperature is about 70° F. The annual precipitation varied in five years from 23.71 inches to 69.66 inches, the average being 41.27 inches. The average number of clear days was 151 for the year.

Corpus Christi is situated on a sheltered bay on the southern coast of Texas. A fine beach, surmounted by a high bluff, gives a pleasing variety to the scenery. The town is a favorite winter resort for pleasure-seekers. The mean annual temperature is 65.7° F. The mean temperature for the three winter months is slightly under 57° F. The mean annual rainfall is about 29 inches, which is very low for a coast station. The mean relative humidity in 1901 and 1902 varied from 85 per cent. in the morning to 75 per cent. in the evening. The average cloudiness is about 34 per cent.

The western coast of the United States stretches from 32°40′ to the forty-ninth parallel of north latitude. The features of the climate distinguish it in a striking way from that of the eastern coast. These features are, chiefly, equability of temperature and seasonal alternation of rain and drought. The coast line of more than 1300 miles shows a difference of only about 10° in the mean annual temperatures. "One of the most noticeable differences between the climates of the Atlantic and Pacific seaboards is found in the trend of the isotherms, those of the Atlantic coast corresponding more or less with the parallels of latitude, while on the Pacific coast the isotherms run more nearly like meridians."[35] The mildness and equability of the coast climate are due to the proximity of the relatively warm waters of the Pacific, and to the constant easterly movement of the wind carrying inland the warmth of the ocean. The ridges of the Cascade and Sierra Nevada mountain chains run parallel to the coast, and tend con-

tinually to discharge the moisture of the humid west wind. These conditions give to the eastern and western portions of the coast States extraordinary differences of climate, the former being very dry and the latter extremely moist.

The climate of the coasts of the States of *Washington* and *Oregon*, the northern border of the former coinciding with the forty-ninth parallel of north latitude, presents an anomaly in that the temperature is much higher and more equable than is usual so far north. *Seattle* and *Tacoma*, Washington, are thriving cities, situated on an arm of the sea that penetrates far inland. *Portland*, the chief city of Oregon, is situated on the Willamette River, near its entrance into the Columbia; and *Astoria* is a small fishing town, built chiefly on piles washed by the tide, near the mouth of the Columbia River. These places have not won repute as health resorts on account of the large number of rainy days and frequently overcast sky which distinguish them. But there is a growing opinion that the climate may be of great value as a nerve-sedative, without depressing influence. The populations of the places are characterized by thrift and energy. *Seattle*, in 1903, had a mean maximum temperature of 58° F. and a mean minimum of 45° F. The mean relative humidity was 76 per cent., precipitation, 34.55 inches; clear days, 96; cloudy, 143. *Tacoma*, somewhat further south, had a lower temperature, 45.11 inches precipitation, and only 42 clear days. The amount of yearly precipitation is very variable. *Portland*, latitude, 45°32′ N., has a mean temperature of 52.4° F., with a mean for winter of 41° F. and for summer, 64.2° F. The average yearly precipitation is 54.18 inches, only about 3 inches falling in summer. The mean relative humidity for winter is 78.7 per cent.; for summer, 65.1 per cent. Average number of clear days, 85.5.[36] *Astoria* has a somewhat colder and moister climate. Beach resorts fronting the ocean are accessible to it and afford fair hotel accommodations.

On the coast itself there is seen, well illustrated at San Francisco, the struggle, as it were, between the meteorologic conditions determining a marine or a continental climate. At San Francisco the mean annual temperature is 56.1° F. The month of lowest mean temperature is January—50.2° F.; the warmest is September—60.8° F. The relative humidity varies from about 74 to 90 per cent. of saturation. The annual rainfall varies from 15 to 24 inches. The wind movement is almost constant, and often severe in exposed situations. "Overcoats and heavy wraps are worn in midsummer, while the lilies bloom in December. From May until September very little rain falls, yet during this period, with clock-like regularity, great banks of fog march in every afternoon and cover the bare brown hills. . . . Visitors to the city should by all means wear heavy wraps or overcoats during the summer afternoon"[35]—a striking illustration of how moisture and wind may affect the *sensible* temperature, while the air thermometer shows very little change.

It is *southern California* that displays in various parts an extra-

ordinary diversity of climatic conditions, prized in health resorts, and which have caused its coast to be likened to the Riviera and portions of the interior to Egypt, while its eastern borders are purely desert wastes. South of San Francisco, 125 miles by rail, is the old Spanish town of *Monterey*, on the southern shore of the Bay of Monterey, the town of *Santa Cruz* lying opposite on the northern shore. At Monterey the mean temperature for January is 50° F., and for July, 65° F. In the middle of the forenoon the temperature of the air and that of the water are nearly identical throughout the year. The mean annual rainfall is 14.4 inches, and fogs are more or less prevalent at night and in the morning. Hinsdale[20] says: "Monterey is admirably furnished with all the luxuries of a seashore resort, . . . and is provided with a palatial hotel, the famous El Monte. With a superb beach, perfect roads, hills, valleys, and ocean, nothing could be more delightful to a convalescent than to rest a while at this resort. It is eminently suited to those who need rest, relaxation from business and other cares, or who have been exhausted by chronic, nervous, or febrile disease. It is well suited for the relief of insomnia. Pulmonary tuberculosis is not favorably influenced here or at Santa Cruz." It may be suggested that splendor of surroundings has in itself some power to draw on *ennui* of spirit, as too rich and varied a cuisine dulls the appetite.

Santa Barbara (34°23′ N. latitude; population, 6000) is the most noted coast resort. It is situated on a part of the coast line which runs east and west. The town is incircled by foothills, except on the south, where it faces the open ocean; the distinguishing charms of the place are due to these features of protection. The mean monthly temperature of Santa Barbara for winter is 54.4° F., and for summer, 65° F. The mean daily range for winter is 18.5°, and for summer, 17°. The mean relative humidity for winter is 67.1 per cent., and for summer, 75 per cent. The wind blows almost wholly from the west, and its average velocity is less than five miles an hour. The mean annual precipitation is 16.59 inches, nearly all occurring between the months of November and April inclusive. As compared with favorite resorts on the Riviera, Santa Barbara is warmer by several degrees in winter and correspondingly cooler in summer. Unfortunately, foggy weather is not uncommon, especially in summer and autumn. The nights are cool, and the air rapidly chills just before sunset. Dr. W. H. Flint, of Santa Barbara, writes[37]: "Patients with chronic rheumatism, asthma, and advanced tuberculosis generally do badly at Santa Barbara, but the writer has seen several cases of asthma cured by a residence in the foothills. . . . The climate of Santa Barbara and its foothill region exerts a favorable influence upon neurasthenia, cardiac diseases, renal affections, arrested pulmonary tuberculosis, and chronic bronchitis. The last-named disease is particularly benefited by the climate of the foothills. The climate is also admirably adapted to the needs of young children, of people with feeble vitality, of old people, of convalescents from acute diseases, and of all those invalids

and pleasure-seekers who require an abundance of sunshine, pure air, and continuous out-of-door life." Solly says[8]: "This Pacific coast is damp and presents its claims to sufferers on the grounds of equable temperature and sunshine. It lacks the dry air and tonic, stimulating qualities of the elevated inland plains, but offers less shock to the system from rapid changes."

The most southern town on the coast of California is *San Diego*, which has a population of 18,000. The place is extraordinary for its equable climate. The mean temperature for January, the coldest month, is 53.9° F., and for August, the warmest, is 70° F. The average daily change of temperature from day to day is two degrees. The relative humidity is high, ranging from an average of 74.4 per cent. in January to 81.5 per cent. in September. Now and then, for short periods, an east wind from the desert makes the air very dry. The annual rainfall is very variable, but the mean for fifty years was 9.52 inches; the drier season extends from April to October inclusive. There is an average of 166 clear and 45 cloudy days in the year. The hourly wind movement rarely equals five miles.

Opposite San Diego, and forming part of the barrier for its very fine harbor, is *Coronado Beach*, on which are established a great hotel and a tent and cottage colony. The place presents an ideal equable marine climate. Mention may be made of the charming village of *La Jolla*, 17 miles by rail north of San Diego. The cliffs of soft sandstone here give a life to the breaking waves that adds zest to the peaceful monotony of a restful climate. Unfortunately, as yet, there is no good hotel, but visitors can rent pretty cottages at low rates.

INLAND CLIMATES AND RESORTS OF LOW AND HIGH ALTITUDES

As already indicated, the chief distinguishing feature of continental as contrasted with marine climates is in the lower humidity of the former entailing a greater variability of temperature, greater heat in summer and cold in winter, and, in general, corresponding stimulation of the reactive powers of the body. Inland climates may properly be divided into *warm* and *cold*, the former being utilized only in the winter season.

Egypt has acquired a great reputation as a winter resort. Weber and Foster[10] describe its main climatic characters as: "(1) Warmth, the mean temperature at Cairo for the winter months being 58.3° F.; (2) *large daily range*, the difference between day and night temperatures varying from 35° to 19° F.; (3) *low relative humidity;* (4) *abundant sunshine*—blue sky was chronicled on all but fifteen days during five months at Assouan in the winter of 1892–93; (5) *small rainfall;* six rainy days only in five months were chronicled at Assouan in 1892–93; and (6) *the extremely aseptic character of the air*, which is constantly refreshed by a breeze blowing over hundreds of miles of desert, whence no evaporations arise." The days are warm and bright, and the nights cool. The relative humidity is very low,

and the daily temperature range is less in the desert away from the oases. The chief disadvantages of the climate are said to be the occasional cold winds, or, worse, hot winds laden with irritating dust.

The climate is said to be bracing to the body as a whole, while sedative to the nervous system. Invalids should not remain long in Cairo or its neighborhood. Fogs may cover the Nile for 100 miles south of the city. As in most warm countries, but scant provision is made to provide artificial heat on the frequent occasions when the air feels chill. Physicians who have had experience with the effects of the desert climate of Egypt upon the course of pulmonary tuberculosis give it the highest praise. Unfortunately, suitable accommodations for the feebler class of invalids are very inadequate. Travelers usually limit their sojourn in Egypt to the period between October and the end of April.

A long journey brings us to a region offering certain resemblance to Egypt—the territory of *Arizona* in the United States. It is included, roughly, between the thirty-first and thirty-seventh parallels of north latitude, and one hundred and ninth and one hundred and fifteenth meridians of west longitude. The territory embraces extensive regions, affording extraordinary variety of climatic conditions. The resources of the country have been so little developed that suitable accommodations for travelers and invalids are to be found only at a few scattered points. About one-third of the area of Arizona, in the southwest portion, is largely desert, and includes in the neighborhood of the Colorado River some of the driest and most desolate land on earth. This region is a low plain, and has a rainfall of only from 2 to 6 inches yearly. Eastward the plain rises gradually in altitude, and the remaining two-thirds of the territory may be divided into two plateaux, interspersed with mountain ranges, one plain lying at an altitude of 3000 to 5000 feet, and another, embracing more than half the territory, lying above the 5000-foot level (Solly). The mean annual rainfall for the whole territory is 11 inches, reaching 20 to 25 inches in certain districts. The rain is confined to two seasons—winter and summer.

Phoenix (altitude, 1100 feet; population, 10,000) is much frequented as a winter resort of low altitude. The average annual rainfall is 7 inches. The humidity is low, and there is marked difference between temperatures in the sun and shade. The average temperatures are: for winter, 51° F.; for summer, 87°. The days may be very hot, the mercury sometimes rising to 100° in April. The nights are cool or cold. The sky is usually cloudless, and the rate of wind movement averages little over two miles an hour. Accommodations for invalids leave much to be desired in Phoenix, though there are various outlying ranches and tent colonies where strangers are provided for. The country neighboring Phoenix is naturally arid, but has been extensively cultivated by the help of irrigation.

Accessible to Phoenix are the *Castle Creek Hot Springs* (altitude, 1971 feet), where good accommodations may be had. In the six months from November to April in 1901–02 the average maximum

temperature here was about 74° F.; the average minimum, 44° F. There were 168 clear days, 12 cloudy, and 1 with rain. Tuberculous patients are not received. *Tucson* (altitude, 2400 feet; population, 6000) is an old Spanish town, seated in a dry basin, hemmed in by massive mountains. The winters are mild, the humidity is very low, extensive irrigating being impossible, and the atmosphere is peculiarly clear. The accommodations of a good hotel are now offered. *Oracle* (altitude, 4500 feet), 40 miles north of Tucson, is an excellent resort with fair accommodations. *Prescott* (altitude, 5300 feet; population, 3000) has a climate which is compared to that of Denver, several hundred miles further north. *Yuma* (altitude, 140 feet; population, 1200) is situated in the desert on the Colorado River. Its summer heat is intense, but, as the mean yearly relative humidity is but 46 per cent., the sensible temperature is not always excessive. The mean monthly temperature for January is 53° F. The average number of days of temperature above 90° during the year is 163; below 32° F., 4; cloudy days, 21.

El Paso (altitude, 3700 feet; population, 10,000) is in the northeast corner of Texas, and belongs climatically to New Mexico. It is well known as a health resort, though its accommodations are limited and the considerable number of invalids is a drawback. The mean annual precipitation is 9 inches. The mean temperature for January is 44°; for July, 83° F. It is purely a winter resort, though an excellent one, although, at times, rendered obnoxious by wind and dust. *San Antonio* (altitude, 650 feet; population, 40,000) is in latitude 29°27′ N., and about 130 miles from the Gulf of Mexico. The mean yearly rainfall is 30.6 inches. The mean temperature for January is 51° F. The air is damp, the winter mild, and the summer hot. The hourly wind-movement is about 7 miles.

California is unique in the variety of its climates. The Sierra Nevada and the Coast Range of Mountains condense the moisture brought from the Pacific, with the result that there is practically a marine climate to the west of the mountains, and an arid or desert region on their east. In the southern part of the State the trend of the mountains is away from the coast, leaving on their west a succession of broad plains and valleys whose fertility and salubrity have made them famous. Solly says:[8] "Directly north and east of the highest part of the southern coast range are the great deserts. The Mohave desert has an average elevation of about 2000 feet. In the southeasterly corner of the State, bordering on the Colorado River, is the low desert-land called the Colorado desert, which in some places is depressed nearly 300 feet below the level of the sea. . . The amount of average rainfall along the southern slope is from 10 to 20 inches, diminishing to 3 or 4 inches over the Colorado desert, and increasing to 40 inches on the highest summits. . . In Los Angeles, over 60 per cent. of the rainfall for the season occurs during these three winter months. . . The coast is cool and moist; the interior is hot and dry." As pointed out by Hinsdale,[20] the very heat of the unin-

habitable interior deserts is a boon to the region west of the barrier mountain chains, for the hotter the air over them, the more powerful is the force compelling the movement of the refreshing sea breeze. The amount of rainfall may vary greatly from the mean in successive years. The air may be fairly dry during the greater part of the day, but, according to Solly, is always damp at night. The humidity and coolness of the air at night give rise to frequent fogs, more common at Los Angeles, 14 miles from the coast, than on the coast itself.

Southern California, in the region embraced between the San Gabriel range of mountains and the coast, well merits the title of the "garden spot of the earth." A sedative, but not enervating, climate, delicate flowers and fruits growing in profusion out-of-doors, an intelligent population, bringing northern energy to bear on a soil of subtropical richness, have made this region peculiarly attractive to the traveler and a source of local pride to the resident. *Los Angeles* (altitude, 330 feet; population, 325,000) is the principal city of southern California. The rainfall averages 18 inches, but is subject to great variations. Fogs are frequent at night and in the morning, especially during spring and summer. The average number for the year is 57. The mean monthly temperature for January is 53°; for July, 72° F. The temperature hardly ever falls below 32° F. Wind-movement is about 5 miles an hour. The amount of sunshine is over two-thirds of the possible. Los Angeles is connected by electric-car lines with numerous neighboring towns, the nearest of which, Pasadena, nine miles away, is a famous residential resort. Further from the coast the fogs are less numerous; the rainfall and humidity are less, and the temperature is higher.

Riverside (altitude, 850 feet; population, 10,000) is well known for its orange groves. The average relative humidity is about 67 per cent. Fogs are relatively little marked; the average rainfall is 10 inches. The mean temperature for January is 50°; for July, 76° F. *Redlands* (altitude, 1350 feet; population, 3500) "is surrounded by mountains from 5000 to 12,000 feet high on the south, east, and north, and lies open to the sea on the west, from which it is distant about 80 miles" (Otis).[38] Vegetation under irrigation is luxuriant. The naturally abundant dust of the roads is effectually laid by sprinkling with crude petroleum. The average rainfall is 15.59 inches, of which nearly all is confined to winter and spring. The average relative humidity is not far from 56 per cent. For January the mean maximum temperature is 62°; the mean minimum, 40°; for July the figures are about 95° and 59° F. On account of the low humidity, high air-temperatures may be attended with low sensible effects. There is considerable difference between the temperatures of day and night, amounting to 20° to 30° F., and at the same time the relative humidity rapidly increases with the fall of temperature, rising as high as 70 or 80 per cent. There is, on this account, a chill in the evening air which is of great moment to the invalid. There are said to be over 300 days of sunshine in the year. The hot, glaring sunlight of summer

is to many intolerable. The beautifully situated *Loma Linda Sanatorium*, about 1200 feet altitude, is 5 miles from Redlands; tuberculous patients are not received. *Mentone*, with a tuberculosis sanatorium, is one mile distant from Redlands. The health resort of *Idyllwild* is beautifully situated, though somewhat difficult of access, in the Strawberry Valley, at an elevation of 5250 feet. Accommodations are offered either in cottages or in the central building. Many conveniences are provided, and there are a resident physician and nurses for invalids, who come chiefly from the curable class of tuberculosis.

The mildness and equability of the climate of southern California have long been attractive to patients afflicted with tuberculosis. The inducements to an open-air life have resulted in much good to this class, but the weight of testimony is against the region as a whole, except at altitudes of 1200 feet or more, which are mostly above the level of the occasional fogs. Moreover, manifestly tuberculous visitors are socially distinctly unwelcome in this region, except in institutions provided for their reception.

Inland Climates of the Eastern United States and Canada.—The places here selected for mention all come within the class of resorts of low or moderate altitude. The enormous territory, nearly equal in area to Europe, embraced within the Dominion of Canada, has been very incompletely exploited. The region may be divided into three climatic areas: (1) The eastern, extending from the coast to and including the Great Lakes, where the extremes of temperature are great and rainfall considerable; (2) the inland, reaching from about Winnipeg to the Rocky Mountains, showing a great range of temperature, but small rainfall; and (3) British Columbia, possessing the general climatic features pertaining to the northern Pacific coast States.

The district of Muskoka, in the Province of Ontario, Canada, offers a good type of what may be called a northern, continental health preserve. The district lies on the eastern shores of Georgian Bay, and the forty-fifth parallel of latitude passes through it. Its area is about 1500 square miles, and its elevation varies from 600 to 1400 feet. Fish and large and small game abound in profusion. The flora is rich. Pine and hemlock and a large variety of deciduous trees are found everywhere. Many beautiful lakes dotted with islands are scattered through the region. Dr. J. H. Elliott[38] writes: "The summers are warm, with, as a rule, cool nights. The mean daily maximum for June, July, and August is 77.4°, and mean daily minimum, 52.3° F. . . . Snow appears in flurries during November, and about December 1st the ground is covered, remaining so until March. . . The lakes freeze over late in November or early in December, and do not open until April. . . Though the air in winter is cold, it is comparatively dry and is not penetrating, and sitting out-of-doors or driving is made very comfortable by means of furs and rugs. The mean temperature for the four winter months, December to March, is 19.1° F., and the mean relative humidity is 81 per cent., the air holding only about 0.9 grain of moisture per cubic foot, or one-third

the moisture of the air at 60° F., which has a relative humidity of only 50 per cent. The mean daily maximum for the four months is 26° F., and mean daily minimum, 9.5°. . . As a rule, the wind drops when the mercury reaches zero or a few points below, and with a temperature of —10 or —20° F. the atmosphere is still and clear. Some of the most perfect days are when the temperature is below this; not a cloud in the sky; the snow crisp and sparkling in the sunlight, and the smoke from fires rising straight up into the air. . . Sufferers from hay-fever have in Muskoka immunity from their distressing attacks. . . It is unusual to see a case in which the symptoms do not disappear within twenty-four hours of arrival, while if the date of attack is anticipated, none of the symptoms develop. Asthma, too, is markedly relieved by residence in Muskoka. . . Pneumonia is comparatively rare. . . Simple anemias are quickly benefited. . . For many years the district has been growing in favor as suitable for the treatment of pulmonary tuberculosis. At first patients were sent only for the summer months, but since the establishment of the two sanatoria of the National Sanatorium Association of Canada, the experience of Trudeau in the Adirondacks has been found to hold here also—that in winter cases do even better than in summer, and its value as a place of winter residence is becoming more recognized. The severe winters are enjoyed by the robust patients, and those whose recuperative powers are good, but render it unsuitable for the advanced case with anemia and poor capillary circulation, who is weak and cannot stand the cold."

At the town of *Gravenhurst*, on Lake Muskoka, are situated an admirable cottage sanatorium and a free hospital for consumptive cases. On the Canadian Pacific railway, a line as it pierces the Rocky Mountains of unrivaled scenic attractions, lie a number of resorts, combining in a marked degree the virtues of northern continental climates. *Calgary* is about 40 miles east of the Rocky Mountains, and has an elevation of 3500 feet. It has a dry, cold, bracing sunny climate. The mean temperature for January is said to be 6.3°, and for July, 59.6° F. The mean daily range of temperature is about from 20 to 30° F. *Banff* (altitude, 4542 feet) is situated in the Canadian National Park, near the eastern gateway of the mountains, and its climate and scenery properly place it among mountain resorts. *Kamloops* (altitude, 1100 feet) is situated in the broad valley, between the Cascade and main Rocky Mountain ranges. The annual rainfall is about 11 inches only, and the number of rainy days, 75. The mean annual temperature is 46.3° F., nearly 10° higher than that of Calgary. The average annual range is but 22.8° F. The hotels are said to be good, and charges reasonable (Solly).

The Adirondacks compose a rolling forest country in the northeastern part of the State of New York. Low mountain chains running northeast and southwest divide the waters of the St. Lawrence from those of the Hudson River. The region is a broken plateau, having a general elevation of 1500 to 2000 feet. Pine, hemlock, spruce, and

balsam abound, and give the air a delicious aromatic odor. Beautiful lakes are scattered throughout the region, which has long been a favorite camping-ground of pleasure-seekers and a resort for tuberculous invalids. The *Adirondack Cottage Sanitarium*, about one mile from the town of Saranac Lake, has gradually developed into a small village of beautiful cottages, around a central administration building. This institution is for the treatment of curable cases of tuberculosis. The results gained under the administration of its founder, Dr. E. L. Trudeau, have been convincing as to the remedial virtues of an outdoor life, faithfully pursued in the pure air of a rather damp and sometimes rigorous climate. The mean annual precipitation of the region is about 39 inches. Snow usually lies on the ground from the middle of November until the end of March. The evergreen foliage covered with a drapery of freshly fallen snow is inexpressibly beautiful. The mean annual temperature for the northern plateau (elevation, about 1580 feet) is 40° F.; mean for winter, 18° F.; and for summer, 62° F. The mercury sometimes falls below −30° F. in winter, and may rarely rise to 90° F. in summer. The temperature is steadily low throughout the winter, and the air then seems dry. The porous, sandy soil dries quickly, and the frequent dampness in the air is offset by the balsamic odor of the evergreen foliage which it develops. A great number of charming resorts open in summer to the pleasure-seeker who can choose between well-conducted, modern hotels, such as are found at Lake Placid or the Saranac Lakes, rural boarding-houses, and camps pitched on the bosom of nature. Dr. Lawrason Brown[78] writes: "The climate of the Adirondack mountains is cool and moist during seven months of the year; cold and dry during five months. The entire region enjoys freedom from dust and disagreeable winds. The number of clear days is small; the number of cloudy days excessive, and the number of partly cloudy days much below the general average."

Saranac Lake village (altitude, 1600 feet) is the only locality fitted for the maintenance of invalids in winter.

It is impossible in this essay to give a detailed account of the various sanatoria which have been established for the relief of pulmonary tuberculosis, and whose topographic dispositions and general policies have been more or less modeled after the great institutions of Germany, but which are practically outgrowths from the influence exerted by the Adirondack Cottage Sanitarium.*

It seems invidious to select for mention definite resorts along the Atlantic inland; the climatic resources of the region are boundless, and doubtless many of the healthiest situations are quite unsought by invalids. Thus, Dr. Guy Hinsdale[12] has called attention to the comparative rarity of pulmonary tuberculosis in the highlands of Pennsylvania, on the northern border of the State, and in the neigh-

* The reader is referred to the Directory of Institutions and Societies Dealing with Tuberculosis in the United States and Canada, 1904, published by the Charity Organization of the city of New York.

boring counties of New York. From the viewpoint of climatotherapy, this is an unexploited region, having an area of over 12,000 square miles, with elevations varying from about 1000 to 2500 feet above sea-level. Its proximity to great cities makes especially valuable for therapeutic purposes the *pine belt* of *New Jersey*. This is described as a sandy strip of land 60 miles long and 8 to 20 miles wide, well covered by pine forests. The summers are, at times, hot, but the winters are warmer and milder than in New York city. *Lakewood*, lying near the wooded strip, and 10 miles from the sea, is the most commodious resort.

No more convincing demonstration of the virtues of judicious climatic change could be desired than that enjoyed by one who leaves Baltimore on a hot and sultry day in August or September and travels by rail along the banks of the Potomac, and climbs in a few hours to *Deer Park*, in the heart of the Alleghenies, at an elevation of 2400 feet. It is a sudden transposition from the baking heat of paved streets to the cool shade of splendid virgin forests. The air is pure and bracing, and the comforts of an admirable hotel are available. Passing from Harper's Ferry on the Potomac up through the Shenandoah Valley past Staunton, Virginia, the traveler covers a country of rare salubrity and great historic interest. Only here and there have the great natural resources of the rolling woodlands and mountain slopes of Virginia been developed as resorts. One of the most noted of these resorts is *Hot Springs* (altitude, 2300 feet), situated in a mountain valley. The air here is drier, purer, and more invigorating than in the great cities; the winter cold and summer heat are milder. According to Hinsdale,[38] the highest recorded temperature was 98° F., and the summer nights are cool. The average annual rainfall is 40 inches. The natural thermal springs of the neighborhood are famous. An admirable hotel and facilities for hydrotherapy under a skilled physician are at the disposal of visitors. It is said that the resort offers "the best combination of means for the successful treatment of gout, rheumatism, and many nervous disorders, including insomnia, neurasthenia, hysteria, hypochondriasis, and malnutrition."

Asheville, North Carolina (altitude, 2250 feet; population, 10,000), is beautifully situated on an elevated plateau, with distant vistas of mountain chains and two fine rivers near at hand. It is a favorite resort both for pleasure-seekers and for patients suffering with tuberculosis. The mean monthly temperature for winter is said to be 38° F., and for summer, 71° F. The mean annual relative humidity is 69 per cent., and the rainfall, nearly 46 inches. February, March, July, and August are the favorite months for visitors. There are more than 250 fair days in the year. The winds of winter and spring are sometimes keen, and patients need not expect uninterrupted balmy weather. The sandy soil and pine forests which cover large parts of South Carolina and Georgia should make these regions valuable winter resorts.

Aiken, South Carolina (altitude, 550 feet; population, 2500),

is such a place. The mean winter temperature here is given as 48° F., and for the same season relative humidity, 59 per cent., and number of cloudy days, 31. The mean annual rainfall is 48 inches. The average wind-movement is only 3.5 miles an hour, though the velocity is occasionally much greater (Solly). A cottage sanatorium of limited accommodations for tuberculous patients is found here.

Summerville,[23] a suburb of Augusta, Georgia, less than 20 miles southwest of Aiken, is said to be a charming and healthful winter resort, with a fine hotel, where limited but appropriate accommodations are available for invalids.

Thomasville, Georgia (altitude, 330 feet; population, 5500), is in the pine woods in a moist air. The mean temperature of winter is said to be 50° F., relative humidity, 67 per cent., and rainfall for the season, 11½ inches (Solly). The accommodations are good. The climate is said to be sedative, at times relaxing, lacking the stimulating qualities of the northern woods. *Chattanooga*, Tennessee (altitude, 700 feet; population, about 50,000), should be a favorable spot for a convalescent. The town lies at the base of Missionary Ridge, on one side, and is dominated by Lookout Mountain, on the other. The scenery is superb, and every spot is replete with historic interest of some of the most picturesque conflicts of the Civil War. The mean monthly temperature for winter is about 43° F.; for summer, 77° F. The average yearly relative humidity is about 74 per cent., and average number of fair days, 147. The wind-movement averages 5.9 miles an hour; annual precipitation, 52.81 inches. The protected position of the town is adapted to exaggerate the extremes of sensible heat and cold; a wide variety of climatic conditions can be obtained on the surrounding elevations. The air is pure and exhilarating.

Among inland resorts of low altitude the region of the *Great Lakes* is peculiar in combining some of the features of marine and continental climates. In winter the weather is often rigorous, but in summer the air has all the purity and freshness of the open sea, with the added charms of beautiful scenery here and there on shore. A charming trip is said to be that by the commodious lake steamers passing between Buffalo, at the foot of Lake Erie, and Duluth, at the head of Lake Superior, a voyage of about 1000 miles. The trip eastward, down the St. Lawrence River, among the Thousand Islands, to Montreal and to the quaint and ancient city of Quebec, is a journey not to be excelled in beauty and interest. At the apex of the lower peninsula of Michigan, where the waters of Lake Michigan and Lake Huron merge, is Mackinac Island. This is a delightful spot, where an almost marine climate of the most stimulating but restful kind can be enjoyed in summer under the shade of the wooded hills. No figures are available for Mackinac, but at St. Ignace, on the neighboring mainland, the mean temperature for June is 59.6° F.; for July, 64.3°; for August, 62.6°. The rainfall is 22.05, and the (unmelted) snowfall, 37 inches.

Inland Climates of High Altitudes.—The general meteorologic attributes and physiologic effects of high altitudes have been previously discussed. It may be repeated that the distinguishing physical feature of elevated resorts is the reduced barometric pressure, which affects the living organism most obviously through the circulatory and respiratory mechanisms. Important physical adjuncts to diminished air-pressure are lowered absolute and relative humidity, more complete diathermance of the air, greater difference between the temperature in the sun and in the shade, less cloud and more sunlight, the preponderance of actinic rays, greater purity of the air, and increase in the rate of evaporation. It may be rightly judged, from consideration of these facts, that the characteristic effect of high altitude upon the living organism is, more or less, one of stress and stimulation. The physiologic influence is beneficial when the reactive power of the individual is good, but, as pointed out by J. T. Eskridge,[39] it may be adverse when the strain is thrown upon organs weakened by age or disease and lacking vital resistance. The high-altitude resorts that will be considered are confined, in Europe, to the mountains of Switzerland, and in America to the eastern slope of the Rocky Mountains. The former are distinguished by greater humidity, greater precipitation, especially in the form of snow, and, as a rule, by less sunshine than the latter. On the other hand, there are few places in America where a patient enjoys so thorough trained medical supervision as is common in the resorts of Europe. A great drawback, in some respects, to the availability of health resorts in the treatment of chronic diseases is in their isolation from the centers of human interest, and the impossibility of a breadwinner earning a livelihood while working out a cure of his disease. Herein lies one great advantage of the Rocky Mountain region, especially as represented by the larger communities in the State of Colorado.

Certain resorts of the Swiss Alps have acquired great fame from their favorable effect upon the course of pulmonary tuberculosis. *Davos Platz* (altitude, 5120 feet) is the most noted of these. It is situated in the valley of Davos, which is half a mile wide and watered by a stream. The resort itself is well sheltered from the cold winds, and lies partly on the slope on the sunnier side of the valley. Winter is the season of choice for invalids. The ground is usually covered with snow from early December until late in March. The air is, therefore, free from dust, which is an obnoxious feature of the Rocky Mountain slope. As in all high altitudes, there is great difference between the temperatures of sun and shade. A difference of 70° F. has been noted between the mean maximum temperatures of sun and shade for December. "Even in the shade and when the sun has set the dryness and stillness of the air prevent the low temperature from being felt so much as it would be at low elevations." The mean annual temperature is 36.7° F. The average of the monthly means from November to March, inclusive, is 23.6° F. The mean annual relative humidity is 79.7 per cent.; the average of monthly

means for the five months, from November to March, is about 81 per cent. For the same period the total amount of actual sunshine was 565.3 hours, or only about 3.7 hours a day. The markedly greater proportion of sunshine and the lower humidity of Rocky Mountain resorts will be noted later. The total annual precipitation, rain and melted snow, is 33.6 inches, of which 12.5 inches fall in winter and spring. The wind-movement is very slight, the mean velocity for winter being 1.6 miles, and for spring, 2.5 miles per hour (Solly). Sanatoria for both free and pay patients exist at Davos, and there are few open resorts where an invalid may come so completely under the direction of skilled medical counsel.

Arosa (altitude, 5700 to 6090 feet) is a winter and summer resort separated by mountains from Davos. It has a somewhat higher winter temperature, more sunshine, and lower relative humidity than Davos. The mean annual relative humidity is 64 per cent., and 4° or 5° lower for the winter months. From November to March, inclusive, there was a daily average of slightly more than four hours' actual sunshine. The mean annual temperature is 37° F. The average of the monthly mean temperature for the five winter months is about 26.5° F. There is a sanatorium for consumptive patients at the higher level of the resort.

High Altitudes in the United States—Colorado.—Colorado is nearly a parallelogram in shape, and is included between the thirty-seventh and forty-first parallels of north latitude, and the one hundred and second and one hundred and ninth meridians of west longitude. Its area is about 103,000 square miles. The main range of the Rocky Mountains traverses the western half of the State, breaking up into a number of parallel chains, distinguished by many peaks varying in height from 11,000 to more than 14,000 feet above sea-level. East of the mountains, a rolling plain gradually ascends from the Mississippi River through a distance of 700 to 800 miles, reaching elevations of from about 5300 to 6500 feet at the foothills of the Rockies.

The face of the foothills is fissured by numerous cañons bearing mountain streams, which wind their ascending way among the mountains, now and then opening into broader valleys which present some of the most characteristic charms and features of the mountain climate. Especially worthy of mention are those elevated plateaux known as "parks," which are held in the lap, as it were, of the mountains, far within their fastnesses. They vary in area from a few acres to many square miles, and in altitude from 7500 to more than 9000 feet.

On the plains the rainfall is so small that the agriculturist cannot depend upon it for the development of ordinary crops until a distance of some 390 miles east of the foothills is reached, which is between the ninety-eighth and ninety-ninth meridian, or near the middle of Kansas.

The arid region has, however, been made in parts very productive under artificial irrigation, and the face of the country has been greatly changed in recent years wherever irrigation has been possible. Of late, crops have been successfully cultivated by the practice of so-

called "dry farming," in which the natural moisture is conserved in the soil by its fine trituration. Broad stretches of dry plains to the north and east and mountain precipitation on the west leave for the chief source of rainfall on the eastern mountain slope the Gulf of Mexico, some 900 miles away, and intervening plains on the south. To quote from Solly's work:[8] "For the purposes of health resort stations the climate of Colorado may be divided into three groups: first, the prairie plains, ranging from 4000 to 5000 feet in elevation; second, the foothills and adjoining valleys, varying from 6000 to 7000 feet; third, the natural parks, varying from 7000 to 10,000 feet."

The rainfall of the State varies from 8 to 22 inches per annum; along the eastern slopes of the mountains it averages between 14 and 15 inches. The fall is usually greater in the mountains, but in some open places of high elevation the rainfall is less than on the plains. The so-called "rainy season" is in the summer, when afternoon showers of short duration are of frequent occurrence, the night and mornings being clear. The afternoon showers are occasionally sharp downpours, with thunder and lightning and sometimes hail.

The important features of the Colorado climate are low barometric pressure; low absolute and relative humidity; small precipitation; large amount of sunshine; great difference between the solar and shade temperatures and between temperatures of day and night; frequent illustrations of electric accumulations, manifested by slight shocks on touching conductors; a fairly constant but relatively low rate of wind-movement; great purity of air, with conditions impeding putrefaction; dead animals dry up and crumble where they fall, away from the centers of population. Except on the mountains, the snow rarely lies more than a few days at a time in winter, and the dry ground is easily stirred to form dust. Several times a year, especially in the autumn, the dwellers of Denver and Colorado Springs may expect the so-called dust-storms, during which the air is suddenly darkened by wildly flying dust and débris, which, for a few minutes, make it necessary to retreat within doors. It is a variable climate. The summer sun is hot, but the shade is cool. The heat is rarely oppressive—is rather irritating than depressing. Sun-stroke rarely, if ever, occurs. The nights in the open air are always cool, and demand blankets for the sleeper. The winters may have "cold snaps," when the mercury reaches 20° F. below zero, but invalids may sit and even sleep out-of-doors in comfort with the mercury below zero. In winter the characteristic weather condition is one of a mild degree of cold, tempered by bright, warm sunshine. The physiologic result is a feeling of invigoration from the former, with one of comfort without relaxation from the latter. The psychic effect of such conditions may be likened to the exuberant feeling of well-being experienced on an early morning in the late spring in New England. The organism is never cloyed with what may be called the normal Rocky Mountain weather. March and November are commonly pleasant months, when breezy gusts may annoy, but there is no prevailing strong wind.

It is in April and May that unpleasant surprises may be expected in the way of stormy weather; winter is then likely to reassert itself, with the climax of a considerable snowfall. Another frankly wet day or two is to be expected in late September or October. Sometimes the first announcement of winter is a considerable snowfall, which catches the trees in full leaf and does some damage to vegetation. Except when the ground is sodden at intervals during the winter and spring, outdoor sports—tennis, bicycle-riding, and the like—may be enjoyed without intermission. For one who would visit the eastern slope of the mountains, the winter time offers the greatest contrast to conditions prevailing at the same time in the East. During the summer the visitor should seek the mountain parks and cañons. Colorado is somewhat warmer than Wyoming on the north, and cooler than New Mexico on the south. Its chief claim to distinction over these sections is in the large number of health resorts, urban and rural, which are available to the invalid. *Denver** (altitude, 5280 feet; latitude, 39° 45′ N.; longitude, 105° W.; population, about 213,000) is the capital and principal city of Colorado. It is a beautiful and well-kept city, situated about 14 miles east of the foothills and 35 from the main range. The Rocky Mountains, for a stretch of 150 miles, form the western horizon. The smoke of manufactures rarely renders murky the air of the business centers, and flurries of dust occasionally disturb the pedestrian. The people carefully trim and water the grass and trees which line and beautify the residence streets of the city. The moisture from this irrigation probably appreciably affects the humidity of the air. Dr. S. A. Fisk[40] has compiled an interesting table of meteorologic *data*, which follows, slightly modified, on p. 570, and shows some points of comparison between the climate of Denver and that of a number of widely scattered sections of the United States.

It will be seen that both actual and relative humidity are very low, and the total precipitation is but 15.33 inches. The total wind-movement is about 9 miles an hour, comparatively small, though the air is seldom completely at rest. Tornados are unknown, and high winds are rare.

As to the sunshine element, which proves so important a feature of a health resort, Denver is compared by the same writer in the table on p. 570 with other well-known places.

For the same year Denver had 62 per cent. of possible sunshine; Tucson, 82 per cent.; Santa Fé, 70 per cent.; and Portland, 30 per cent. The Swiss resort Davos is commonly contrasted with Denver because at the same altitude. In the winter of 1891–92, during the months of November to February inclusive, the actual amount of sunshine at Davos on an average per day was 2.9 hours, which was 48 per cent. of the possible. At Denver, during the same period, the actual number of hours of sunshine per day was 6.8 hours—69 per cent. of the possible.[12]

* Except as to Denver and Colorado Springs, the estimates of population are drawn from the census of 1900.

TABLE I.—METEOROLOGIC DATA FOR TEN YEARS, COMPILED AT THE DENVER WEATHER BUREAU OFFICE.

Stations	Elevation	Mean Actual Pressure	Mean Relative Humidity	Mean Absolute Humidity (Grains, Vapor)	Mean Precipitation	Mean Temperature	Prevailing Wind Direction	Average Daily Wind-movement	Number of Days: Clear	Number of Days: Partly Cloudy	Number of Days: Cloudy
Augusta, Ga......	196	29,923	74	4.54	45.26	64	NE	92	132	134	99
Boston...........	126	29,885	72	2.76	41.19	48	W	270	118	143	94
Chicago..........	824	29,270	73	2.66	35.10	48	SW	254	108	143	114
Denver...........	5287	24,744	52	1.89	15.33	49	S	169	150	164	51
El Paso, Tex......	3796	26,245	44	2.38	8.60	63	NW	140	217	115	33
Ft. Grant, Ariz. ..	4812	26,226	43	2.38	16.66	60	N	163	207	113	45
Jacksonville, Fla..	43	30,050	78	5.76	53.96	69	NE	149	119	152	94
Los Angeles......	330	29,634	72	4.23	19.54	62	W	119	178	139	48
New York.........	185	29,865	73	3.08	46.83	52	NW	231	107	156	102
Olympia, Wash...	44	29,994	81	3.31	46.80	50	S	79	102	111	152
Philadelphia......	117	29,948	71	3.19	40.45	54	NW	232	113	139	113
Portland, Ore.....	118	29,955	76	3.31	44.11	53	NW	123	110	118	137
Salt Lake City....	4346	25,643	54	2.21	16.00	52	NW	121	153	130	82
San Antonio......	722	29,258	68	4.86	30.46	68	SE	175	114	148	103
San Diego........	93	29,919	76	4.38	12.28	61	W	132	162	138	65
Santa Fé.........	7042	23,293	48	1.67	12.97	49	NE	165	186	133	46
St. Paul, Minn....	850	29,116	74	2.29	24.72	43	NW	166	95	165	105
Washington, D. C.	112	29,963	72	3.31	48.22	54	NW	138	118	142	105

Note.—Ft. Grant, barometer mean for nine years only; San Antonio, means for 1885 for ten months only; Santa Fé, all means for nine years only.

TABLE II.—DURATION OF SUNSHINE (HOURS AND TENTHS)—1892.

Stations	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
Denver...........	5.9	6.0	6.6	8.8	6.0	11.1	8.7	9.4	9.6	7.0	6.7	6.4	7.8
Philadelphia.......	3.6	3.5	5.5	5.8	6.6	8.2	*	8.2	8.4	7.1	4.2	4.0	5.9
Portland, Ore......	1.4	2.5	†4.0	3.5	7.3	7.3	8.5	†8.7	4.7	*	*	‡1.4	4.9
Salt Lake City.....	2.8	4.0	5.6	4.5	8.0	11.0	12.4	11.1	10.8	7.0	5.5	3.2	7.2
San Diego.........	5.9	4.6	7.1	9.2	6.4	8.2	9.4	8.3	9.0	7.4	7.6	7.0	7.5
Sante Fé..........	†4.4	6.7	7.2	9.8	10.9	13.3	11.4	9.9	9.8	7.0	7.2	6.9	8.7
Tucson............	*	*	*	*	*	13.0	10.2	10.3	10.7	9.5	8.7	8.1	9.6
Washington.......	3.6	3.7	5.0	5.8	7.9	9.6	9.0	9.2	8.1	7.3	4.3	4.5	6.5

* No record † For sixteen days. ‡ For twenty-eight days.

The difference is due, as is obvious, both to the relative amounts of cloud in the sky and to the different intervals between sunrise and sunset. As to temperature, Denver is to be included in the list of cool resorts. On account of the altitude and the dryness of the air, the heat of summer gives a much lower sensible temperature than would be expected, especially in the shade. In the winter the cold, as registered by the mercury, makes little or no impression on the person who sits under the direct rays of the sun. This extraordinary difference between the temperatures in the sun and shade is illustrated in the data collated

by Dr. Fisk for the year 1880. The sun temperatures were registered by a thermometer with blackened bulb suspended *in vacuo*. The table confirms the results of common experience, that, for the most part, the sun temperature in Denver throughout the winter is pleasantly warm, while places near the same latitude along the eastern coast may be wrapped in snow and shivering under winter storms. Denver possesses a number of good hotels and a great number of boarding-houses, some of which are open to invalids. The "Home" and the "Adams Memorial Home" are open institutions for the reception of pulmonary invalids, which are conducted with the cleanliness and elegance to be found usually only in the best sanatoria. The "Agnes Memorial Sanatorium," established at Montclair, a suburb of Denver, is a closed institution under medical control, which possesses every advantage that situation and construction can give.

TABLE III.—DENVER, COLO., MEAN TEMPERATURE—1.00 P. M

1886	Solar	Air	Difference
January	92.5	27.3	65.2
February	106.3	48.0	58.3
March	107.8	41.1	66.7
April	110.6	52.3	58.3
May	141.3	74.3	67.0
June	142.2	75.1	57.1
July	146.5	85.2	61.3
August	143.7	81.5	62.2
September	132.3	72.0	60.3
October	119.5	64.2	55.3
November	100.0	41.3	58.7
December	100.2	45.5	54.7

Colorado Springs (altitude, 6000 feet; population, 30,000) is 75 miles south of Denver, 5 miles east of the foothills of the mountains, and only 12 miles in a direct line from the summit of Pike's Peak. The streets are broad, the houses are detached and architecturally attractive, the air is smoke free, and its transparency is accentuated by the ever-shifting shades and surface details of the nearby mountains. The town is built, for the most part, on porous, gravely soil, and the drinking-water is pure. Solly writes: "The rainy months are from April to August, inclusive, the most protracted season being usually a period of four or six weeks of daily rains, beginning during the last half of July. In the mountains these rains are more severe, but on the plains they frequently amount only to afternoon showers. The total yearly rainfall averages 14.46 inches; of this, the normal precipitation is 11.18 inches during the five months from April to August inclusive." The scant fall of snow in the winter lies but a short while before melting, and the porous soil quickly dries. "During the three winter months the number of cloudy days does not average more than five a month. The effect of such an air is bracing and genial, and being so dry, the cold in the shade is little felt, a medium-weight wrap being all that is needed.

The roads are good and seldom obstructed by snow or mud, and the neighboring hills and plains are full of interesting points to visit, and pleasant, sheltered nooks where the invalid can rest under the agreeable heat of the sun, and eat his midday meal without fear of catching cold (Solly)." The monthly mean temperature for January is 26° F.; for July, 69° F.; for the year, 47° F.; the number of cloudy days in winter, 13; in the year, 57. The annual wind-movement averages 9.1 miles per hour. The relative humidity for winter is 48 per cent.; for summer, 51 per cent. The dew-point for winter is 10°; for summer, 41°; dew, therefore, is practically absent. Hotel and boarding-house accommodations are excellent in Colorado Springs. The fame of the place attracts to it a large visiting population of wealth and refinement.

Manitou (altitude, 6300 feet; population, 5000), 5 miles west of Colorado Springs, nestles at the foot of the mountains. It is more sheltered from the winds than the latter place, and its air is damper. It is famous for its mineral springs, containing soda or iron, and strongly charged with carbonic acid. The hotels are good, and are much sought in the summer season.

Glenwood Springs (altitude, 5200 feet; population, 1500) is on the western slope of the Continental Divide, and is situated near the opening of a cañon through which flows the Grand River, whose waters help to form the Colorado River and make their way to the Pacific. "The principal attraction is the famous Yampa Hot Spring, which flows the enormous quantity of 2000 gallons a minute, at a temperature of 124° F. A large and complete bath-house has been built to utilize this hot saline water under medical direction. There are also vapor caves and an open swimming-pool, 700 feet in length by 100 in width, where outdoor baths may be enjoyed during the entire year (Solly)." It is a unique experience to bathe in the outdoor pool whose water is tempered to about 90° F. in midwinter, while gathering snow from the banks. Rheumatism, gout, syphilis, and certain skin and intestinal disorders are treated here with great success. An exceptionally fine hotel is situated at Glenwood Springs, and is open except in the winter.

Passing notice only can be given to the attractive towns of *Boulder* (altitude, 5300 feet; population, 4000), the site of the State University, 30 miles north of Denver, a summer resort for people from the South; *Cañon City* (altitude, 5300 feet; population, 3800), in the southern part of the State, 45 miles west and north of Pueblo, is well sheltered from the winds, has a mild winter climate, and is near the entrance to the Royal Gorge, through which the Arkansas River flows; the town of *Steamboat Springs* (altitude, 6800 feet; population, 400), situated in a lofty valley surrounded by mountains, where 300 mineral springs, cold and hot, are found within a radius of two miles; *Idaho Springs* (altitude, 7700 feet; population, 2000), situated in an open park in the Clear Creek cañon, 35 miles west of Denver. There are many other towns, scores of ranches, and rustic hotels which afford fair to

good accommodations to the pleasure-seeker during the summer, and in some cases throughout the year. It is the custom of Colorado physicians to send their consumptive patients to one or another of the various mountain parks or cañons for the summer.

Estes Park (average altitude, about 7500 feet) is 60 miles northwest of Denver, and about 20 miles by a mountain stage-road from the nearest railroad. Ascending the last hill of this mountain road, the tired traveler looks over a ridge down upon the beautiful panorama of Estes Park, a rolling, elevated, well-watered valley, about 10 miles long by 6 wide, inclosed in mountains. Ruedi[12] states that for the three winter months the number of hours possible sunshine for Estes Park and Davos are, respectively, 799 and 533. The mean annual rainfall is 16.31 inches. The mean temperature for winter is 24° F., and for summer, 57° F. The relative humidity for winter varies from 38 to 49 per cent. Ruedi contrasts the physical conditions of the Rocky Mountains and Swiss Alps as regards their influence on plant life. Timber line in the former region is much higher than in the latter. "A difference of 2000 feet between Colorado and Switzerland is required to put invalids under the same conditions of fauna and flora." Several hotels, one offering metropolitan luxury, and a number of good ranch boarding-houses are open for accommodation of visitors in the summer; unfortunately, no provision is made for invalids in the winter. The careful medical adviser is cautious in the selection of cases sent to such localities. Invalids can expect no systematic supervision and are prone to indulge too freely in physical exercise under this exhilarating environment.

Manitou Park (altitude, 7800 feet) is a charming open valley surrounded by mountains, 7 miles by a good road from the railway, and is very accessible to Colorado Springs. A good hotel with a series of cottages form the accommodations.

The territory of *New Mexico* lying east of Arizona and south of Colorado has a climate more stimulating and without the extremes of heat noted in the principal resorts of the former, and with less cold than often occurs in the latter. New Mexico is, for the most part, an elevated plain which varies in altitude from 3500 to 7000 feet. The rainfall is variable, averaging 13 inches for the territory. *Santa Fê* (altitude, 7000 feet; population, 7000) is an interesting old town of Spanish antecedents. The average temperature for January is 28° F.; for July, 70 ° F. The maximum temperature rarely reaches 90° F., and the yearly average number of cloudy days is 48. The annual mean wind-movement is 6.4 miles an hour. There is a hotel and a Sister's sanatorium. *Albuquerque* (altitude, 5000 feet; population, 8000) is a progressive town having the same characters of sunshine, humidity, and temperature. The mean annual rainfall is said to be about 8 inches. *Silver City* (altitude, 5800 feet; population, 3000) is in the southwestern part of the territory. It has a good reputation as a health resort; the winters are mild and the weather is not subject to sudden changes. The mean winter temperature is 37° F., and the summer, 72° F.

"In ten years there were only 22 days above 90° and 6 days below 10°. The annual average precipitation, based on a record of twenty years, is 14.58 inches, of which 8.11 inches usually fall in July, August, and September (Solly)." The number of cloudy days during the year is 37. The relative humidity for one year was 50 per cent. The town is well sheltered from the wind. Tuberculous patients can find the advantages of sanatorium life.

Las Cruces (altitude, 3800 feet; population 3000) is a Mexican town in the southern part of the territory, about an hour by rail north of El Paso. The yearly rainfall is about 7 inches; the number of cloudy days in one year, 20. The mean temperature for January is 39° F. Accommodations are fair, and the climate in winter is one of the best for tuberculous patients.

Mexico, extending from about the thirty-second parallel to below the fifteenth parallel of north latitude, presents the anomaly of a temperate climate in a tropical setting. The interior of the country is a broad tableland, varying from 6000 to 8000 feet or more in elevation. The ranges of mountains bordering the tableland on either side include many of the highest peaks, some of them active volcanoes, on the continent. The country is divided climatically into the hot zone, extending from sea-level to 3000 feet elevation, the temperate zone, from 3000 to 5000 feet, and the cold zone, which comprises the great interior region, above 5000 feet.

The *City of Mexico* (altitude, about 7400 feet; population, 350,000) is said to embody a suggestion of many European cities in its construction. "It combines the sumptuousness of a little Paris with the beggardom of Naples, the activity of a city of the north with the dull inactivity of a city of the South."[41] The health of the city formerly suffered greatly from inadequate sewage disposal, but this drawback is said to have been successfully overcome by the construction of a great drainage canal. The dry season reaches from about November to April. Nearly all the annual 24 inches of rain falls during the remaining months. The mornings are usually clear, but it may rain heavily during the afternoons and nights. The temperature rarely exceeds 86° F. or falls below 35° F. The mean temperature for winter is 54° F. The hottest month is May, with a mean of 64° F. The mean relative humidity varies from 56 per cent. in winter to 68 in summer.

Guadalajara (altitude, 5100 feet; population, 100,000) is on a branch line west of the Mexican Central railway, and 130 miles from the Pacific Ocean. It is said to be a very attractive city, with comparatively good sanitary conditions. According to Solly, the mean annual temperature is 67° F., the mean for winter being 60° F., and for summer, 72° F. "The rainfall from November to April was about 2 inches, leaving about 35½ inches from the months May to October." The mean relative humidity varies from 49 per cent. in winter to 61 per cent. in summer. In charm of climate and varied interests to the intelligent traveler the tableland of Mexico is said to be in parts unexcelled for winter sojourn. Invalids should not seek the country unless

able to bear well the fatigues of travel, and adapt themselves to the vicissitudes implied in a journey among a tropical and foreign people.

THE RELATIONS OF CLIMATE TO CERTAIN STATES OF DISEASE

There are obviously three points of view from which climate may be regarded as a therapeutic agent: (1) The physical elements embraced in the climate of one place may make it more or less favorable than another to the action of a disturbed physiologic mechanism. Thus, certain forms of heart disease are at a disadvantage in high altitudes, and a patient with acute eczema is apt to do badly at the seashore. (2) The propagation of pathogenic micro-organisms is much more favored by certain climatic conditions than by others. This purely incidental attribute of climate, combined with the poor sanitation practised in many populous communities, is the ruling factor in the geographic distribution of infectious disease. (3) There is a complex dynamic relation of climate to bodily metabolism, and especially to nervous functions, which eludes physiologic analysis. As the mind finds refreshment in a change of occupation or the muscles get rest and improved nutrition by varied exercise, or the appetite is stimulated under a new cuisine, so the organism, as a whole, often has its flagging functions stirred to new and healthy activity by a "change of scene and air," with a certainty and permanency that no drug treatment can rival.

Pulmonary Tuberculosis.—The curability of pulmonary tuberculosis under systematic treatment is a demonstrated fact. Whether that treatment is unconsciously carried out unaided by the patient through devotion to the general principles of hygiene, or whether the result is laboriously achieved with the manipulation of a thousand details in a sanatorium, the general means of cure are the same: life in the open; pure air—pure air all the time; food that nourishes; physical exercise only when the results are physiologic; mental quiet, content, resolution, and hopefulness. These are hygienic measures which operate by improving the nutrition of the cells of the body, with the result that their "resistance power" and machine efficiency are magnified. The *sine quâ non* for the successful treatment of tuberculosis is the proper use of climate in its broadest sense. Suppose that, experimentally, a group of tuberculous patients with septic chills are allowed to remain gathered in winter around a stove in a closed room; and that a similar group, protected by wraps and a wind and rain screen are compelled to remain in the yard outside the wall—no one will doubt that the prognosis for the latter group would be much more favorable than for the former.

This would be strictly an application of climatic treatment, and the good results already achieved in the treatment of tuberculosis in cities under conditions essentially similar have caused the question to be raised, whether the application of climatic treatment, as usually understood, with its banishment from home and at a monetary cost

that impoverishes the average invalid, is necessary or desirable. A long time must elapse before sufficient statistics have been accumulated to answer this question; in the mean while the arguments must be drawn from individual experience or based on *a priori* propositions. There are few clinicians who, while making use of every catholic means of treating the tuberculous poor in city back-yards, would not gladly pitch tents or build cottages for their patients outside the city limits. There are few who have had an opportunity to compare the course of tuberculosis in a patient on the New England sea-coast with that when the same patient removes to the Adirondack woods under similar conditions of life, who do not recognize that the latter locality is more suited than the former to aid recovery from the disease, and the reasons therefor defy definition. The simple fact that patients are apt to improve or retrograde with change of weather conditions is strong evidence of a specific therapeutic action of climate. There is one condition of climate, namely, purity of air, which will be granted as essential to the welfare of every tuberculous invalid. There is probably not one of the other physical elements of climate, except possibly dryness of the soil, which may not be weakened or intensified, as the case may be, with advantage to the patient whom we would place in the environment most favorable to his own vital powers, and hence best fitted to combat his disease. In other words, a few climatic conditions are essential to all patients, and some climatic conditions are best adapted to most patients, but there remains a large minority of the sick whose members have, as it were, a climatic idiosyncrasy, and it is the delicate task of the clinician to pick out the environment best suited to the individual organism.

Cold is, on the whole, undoubtedly a better stimulus to the healing powers than heat; yet a certain proportion of invalids cannot react well to the rigors of a northern winter. A low degree of humidity in the air is, as a rule, favorable to the recovery of most pulmonary invalids, yet certain irritable respiratory membranes demand a moisture and equability which can be obtained only in a purely marine climate. The relatively slender statistics that are available (Solly, Williams, etc.) point clearly to the conclusion that the higher altitudes—from 5000 to 7000 feet above sea-level—are to be credited with a larger percentage of cures in tuberculous disease than any other regions.

Again, in a given location, the results of sanatorium treatment are probably better than those gained among patients living at large. That is to say, a tuberculous patient whose life is ordered under strict and skilled medical supervision is more likely to do well than one who is left to follow his own inclinations. Sanatorium statistics are not to be contrasted with those compiled from open resorts, for, on the whole, patients under the former conditions are selected on the basis of probable curability, while under the latter all comers are received. It probably would not be difficult to select from any large community two sets of patients, one of which, under proper conditions, would give a complete record of cures and the other as uniform a list of

failures. Physicians of large experience with this kind of patients recognize two classes who are least likely to do well: (1) Those who have obviously a low vital resistance power and inherent tendency to retrograde, and (2) those whose mental disposition is characterized by "thoughtlessness," instability, a tendency to injudicious exercise, amusement, or dissipation. The former group needs not only the most hygienic surroundings, but also every facility for care and observation furnished by a modern hospital; the latter group may easily suffer disaster if not under the restraint of a well-ordered sanatorium.

The fact is well established that whatever superiority as a tuberculosis health resort one climate may have over another, such superiority cannot counterbalance the evils of the lack of care in nursing and medical supervision which poverty entails upon an invalid in a strange land. Nor is it wise to strain the reactive powers of a person suffering from very advanced and active disease by the hardships of a long journey to a place whose climatologic conditions admittedly throw on the organism an added burden of readjustment.

If physicians and patients could be brought to realize the truth of these statements, much suffering and squandering of slender resources would be prevented.

Presupposing proper habits of life, it is probable that nearly every one afflicted with tuberculosis may expect a cure of the disease by an early resort to that climate which best conserves his individual powers; where this environment is to be found, whether at home or at a distance, is the x of the individual problem. I have gained my medical experience chiefly at Denver, one mile above sea-level, and I am convinced that the climatic conditions offered by Colorado and similar regions are best adapted to the well-being of most subjects of pulmonary tuberculosis. But there remains, I believe, a considerable minority of consumptive patients for which this region is distinctly unsuited. That is to say, while in Colorado a favorable prognosis can unhesitatingly be given to the great majority of patients in the early stage of the disease, there now and then is found a patient who, while under the most careful supervision and conscientiously following his technical instructions, slips back little by little and must finally be sent home in a hopeless condition. I have been led to the conclusion that too high an elevation above sea-level is the culpable factor leading to such disasters.

In a preceding paragraph reasons were given for assuming that a characteristic physiologic effect of high altitudes is to cause an increase of blood-pressure in the venous system and the right side of the heart. It is tempting to suggest that the very benefits of high altitude may come from a pulmonary hyperemia thus resulting—just as turgescence of the lungs in valvular heart lesions probably develops some degree of immunity to tuberculosis. On the other hand, it is easy to comprehend that a right ventricle, burdened by relative increase of intracardiac blood-pressure, might give way to dilatation and lead to that insidious decline which marks the failure of certain cases. The

clinical basis for this point of view has been set forth elsewhere.[31] It is equally plain that in those subjects whose right heart responds to this hypothetic strain by hypertrophy and increased vigor of action we have fair examples of constitutions which may expect to reach their best efficiency in high altitudes. In patients who are not doing as well as they should, I have many times been able to discover some sign of physiologic weakness of the right ventricle, or, it may be, evidence of a pericardial adhesion, and such patients have greatly benefited by descending to an altitude of 1000 to 2000 feet. Dr. Anderson, of Colorado Springs (altitude, 6000 feet), has recorded the great benefit accruing to a similar class of patients by a winter's sojourn at what he calls an "intermediate altitude"—in this case the Mesila Valley in New Mexico, north of El Paso, where the elevation averages 3500 to 3800 feet above sea-level.[32]

There is some reason to fear that the admirable though meager results of the home treatment of tuberculosis may give rise to a hidebound theory that decries the therapeutic influence of climate *per se*. Hundreds of conscientious and competent medical observers of large experience can indorse the statement of Dr. Anderson, who says, "The history and nature of disease, however similar its manifestations, cannot be successfully treated and combated in any two persons by the same methods or by the same routine remedies. This more particularly holds good as to climate, and its effects upon different individuals who may be suffering from the same disease. Take, for instance, two identical cases of pulmonary lesion, identical in every respect as to personal temperament, amount of area of disease, general symptoms, etc., and we find that the one will steadily lose ground; the disease, instead of becoming arrested or retarded, will advance, and often, if ordered to another and essentially different climate, benefit and frequently ultimate recovery will result to the failing patient" (*loc. cit.*).

Clinical experience is to the effect that cases of pulmonary tuberculosis distinguished by hemoptysis early in the disease do particularly well in moderately high altitudes. But the hypothesis previously advanced as to the tendency of low barometric pressure to cause increased venous blood tension would seem to indicate that residence in high altitudes would be likely to precipitate rupture of a weakened and diseased pulmonary artery. My experience strongly supports the view that, in Denver, as compared with lower elevations, there is a great proportionate excess of hemorrhages, which, judging from their profuseness and the relatively dark color of the blood expelled, result from rupture of a branch of the pulmonary artery.

The future will no doubt furnish us with exact *data* by which we can fit to the individual patient that particular climate which is best suited to his needs. For the present, the clinician must depend chiefly on empiricism, guided by general experience. As regards contraindications for high altitudes, a high pulse-rate in itself seems

not to be a very important factor, agreeing with the recent statement of Bowen, founded on experimental observations, that "a rapid pulse is never an immediate cause of heart-strain, nor a safe indication of how great a strain is present."[42]

Much more suspicious is that important sign of heart weakness manifested by undue acceleration of pulse-rate when a patient rises from a recumbent position or undertakes physical exercise.

In the favorable course of tuberculosis a stage is reached in which the patient is, to all intents, well and capable of meeting fully the essential obligations of life long before the disease is completely eradicated. When this stage is reached by a patient in a climate far from home, the question arises whether the *quasi* invalid may return to his former scenes without danger of relapse from health. One of the most serious indictments brought against "high-altitude cures" is that the changed anatomic and physiologic conditions brought about at high elevations render the patient much more subject to relapse or reinfection when he removes to lower levels. Undoubtedly, a large proportion of invalids who have become functionally well under a given environment, sooner or later meet with disaster after resuming life under conditions which prevailed before the disease developed. These relapses are possibly not more numerous in patients returning home from high-altitude resorts than from any other. The *preventive measures* against relapse are involved in the maintenance of those habits of life under which *quasi* recovery was accomplished. Herein lies the chief virtue of correct medical supervision, a virtue ordinarily much better cultivated in sanatoria and under the conditions of home treatment than in most "open health resorts," that the patient should be brought to see that he is the engineer of his own career; that the hygienic knowledge he has gained must be applied to *retain* as well as to *secure* health.

In a preceding section it was demonstrated that a striking physiologic peculiarity of life at high altitudes is the relative excess of energy required, especially in the unacclimatized, to accomplish a certain amount of mechanical work. This fact has intimate bearing on the welfare of patients with pulmonary tuberculosis.

M. S. Paterson,* medical superintendent of the Brompton Hospital Sanatorium at Frimley, has splendidly demonstrated the complementary relations of rest and exercise in the treatment of tuberculosis. Proceeding on the idea that cure of the patient depends upon the reaction of his organism to autoinoculation, a process which is exaggerated by exercise, but that a rise of body-temperature indicates activity of the disease, his therapeutic effort is to first secure a normal body temperature and then, in the most gradual manner, initiate and increase muscular effort up to strenuous and prolonged exertion. There are probably few exceptions to the wisdom of Paterson's method, in which a mouth temperature of 99° F. in males and 99.6° F. in females is taken as an indication for absolute rest; after which, the

* "Graduated Labour in Pulmonary Tuberculosis," Lancet, January 25, 1908.

temperature not having exceeded normal for some days, the graduated exercises are begun. Familiar as these ideas may seem to the modern student, it is lamentably apparent to the experienced clinician that the medical profession in general has failed to apply them in practice. The experienced physician will recognize that in individual cases the routine of the treatment here advocated must be modified without, however, abandoning its principles.

Tuberculous Laryngitis.—This complication, serious enough at best, no longer necessitates the fatal prognosis that formerly was almost invariably attached to it. Skilled local treatment of the affected organ is of extreme importance, but hygienic surroundings which build up the general bodily vigor of the patient are of still greater value. The common belief that the climatic conditions of high altitudes are unfavorable to tuberculosis of the larynx *per se* is probably well founded. But the activity of the local disease is so largely determined by the general welfare of the patient that one frequently sees it completely arrested or cured when the pulmonary disease improves. I have often watched with surprise the favorable course of tuberculous lesions of the larynx in patients sojourning in Denver who have been the subjects of skilful local treatment.

Other Forms of Tuberculosis.—The effect of climate in increasing the resisting powers of the body is particularly well illustrated in the relative infrequency of forms of tuberculosis which are usually secondary infections. The late J. T. Eskridge was of the opinion that meningeal tuberculosis in children is relatively less frequent in Colorado than in the East—a statement which is very striking in view of the tuberculous ancestry of a large proportion of the young in this region. Dr. George B. Packard, of Denver, whose orthopedic experience is very large, writes: "I am satisfied that the percentage of children suffering from *tubercular joint disease* in Colorado is much less than in moist climates, notwithstanding that a much larger proportion of the parents have a tubercular history."[43] As regards *glandular tuberculosis*, Dr. Leonard Freeman writes: "It is well established . . that tubercular bone lesions are much less frequent in Colorado than in most lower altitudes; and, although I can give no statistics, I have reason to think this is true of glandular tuberculosis also. During a surgical experience of over seven years in Colorado I have seen nowhere near so many glandular enlargements as I observed in an equal length of time in Cincinnati; and the cases have not been, on an average, so virulent."[44] Resort to the seashore is usually advised in strumous conditions, and children affected with tuberculous glands seem to thrive particularly well in the salt sea air. Medical practitioners in Denver see an astonishingly small percentage of cases of *tuberculous affections of the peritoneum.*

Nephritis.—The application of climatic treatment in nephritis is of great importance not only on account of the renal lesions, but to secure compensation for the cardiovascular changes as well.

Hirsch[45] finds the evidence somewhat contradictory as to the natural

geographic distribution of Bright's disease, but, on the whole, the disorder appears to be much more infrequent in hot than in temperate climates. But, as Danforth points out,[46] the form of disease must be considered in order to understand its distribution; lardaceous or amyloid disease of the kidneys is the prevailing type in tropical countries, while parenchymatous and interstitial nephritis are the common forms in temperate regions. The main therapeutic indication is to secure rest for the affected organ through vicarious activity of other secreting mechanisms, especially the skin.

Von Noorden[47] has shown how ill advised for this purpose is the ordinary dietetic treatment of this disease with great quantities of milk. General clinical experience supports the conclusions of Purdy, "that the chief features of climate in the United States which most strongly tend to increase the death-rate from Bright's disease are cold, moisture, and changeability of temperature."[48] The converse holds for warmth, dryness, and equability. Dry cold is not especially deleterious, nor is a high degree of humidity, if accompanied by a warm and equable temperature.

Undoubtedly the safest refuge of these invalids is a rather warm and equable climate. The southern Atlantic States, if free from malarial disease, are to be recommended. Southern California is a locality much favored in this country as a resort for the subjects of chronic Bright's disease. W. A. Edwards[49] speaks highly of the climate of San Diego as a resort in this disorder. The view seems to be very general that high altitudes are distinctly contraindicated for cases of nephritis. There is a certain basis in clinical experience for this view, but it seems probable that only particular forms of the disease are made worse under these conditions.

Admitting the accuracy of the views expressed above as to the increase of venous blood-pressure with altitude, it might be expected that renal congestion produced in this way would sometimes intensify the pathologic condition. Nevertheless, practitioners in Denver and similar situations are constantly seeing examples of apparent recovery from acute Bright's disease, and the writer has observed many instances of the disappearance from the urine of the signs which years before were taken to indicate the existence of a mild form of chronic nephritis. A study of vital statistics gives no basis for the belief that the mortality from nephritis is greater in high altitudes than in similar latitudes elsewhere. In fact, returning to the discussion on a preceding page, of the divergence of the curves of sensible and air temperatures which marks the climates of elevated regions, it seems fair to presume that the "sensible temperature" is a fairer index of the physiologic strain to which the skin and kidneys must respond than that of the air itself. It seems probable, also, that the loss of water from the lungs must be proportionately increased in arid regions, and thus form an important relief to the kidneys.

Diseases of the Heart and Blood-vessels.—The chapter of morbid

physiology which will give rational indications for climatic treatment in this realm of pathology is yet to be written. Cardiac therapeutics has been greatly retarded by the tendency of observers to depend upon *a priori* deductions. While absolute rest is demanded in certain conditions of heart disease, the favorable results of resistance exercises and of regulated hill-climbing demonstrates that the diseased organ fares best under conditions which maintain its nutrition—that is, conditions which secure maximum amplitude of cardiac contraction with a minimum of resistance to the effort. It is not clear why authors advise against a residence on the sea-coast for patients with considerable cardiac dilatation. The common views concerning the influence of high altitudes—5000 to 9000 feet—on heart disease need careful revision. Medical practitioners at these elevations are prone to hurry to a lower level all patients with heart weakness or uncompensated lesions. But, with exceptions to be noted, the writer has commonly found that unmanageable cardiac patients sent to sea-level go to ground as quickly as would have been expected had they remained in Denver.

Dr. R. H. Babcock has probably furnished the key to the problem involved in the relation of altitude to heart disease.[32] He notes that certain patients with *mitral stenosis* do badly at elevations of 5000 feet or more, and gives as an explanation a hypothetic increase of venous blood-pressure and of right-sided intracardiac pressure, which he ascribes to acceleration of the peripheral blood-flow. As has already been seen, there are sound clinical reasons for believing that heightened venous blood-pressure is a normal result of lowered barometric pressure. I was formerly inclined to doubt the position of Babcock regarding the specific incompatibility of mitral stenosis and high altitudes, because of the large number of cases of this lesion enjoying perfect compensation which have come under his observation in Denver. A more careful study of the problem, however, has led me to complete concurrence with the views of Dr. Babcock. While it is common to find at the altitude of Denver perfectly compensated stenotic lesions of the mitral valve, instances frequently occur in which compensation becomes broken, the morbid symptoms being, for a considerable stage from the outset, peculiarly confined to the heart itself and not, as in a regurgitant lesion, involving the whole bodily machinery. Such patients sent to sea-level often make a quick and extraordinary recovery, and after a comparatively brief sojourn may return to high altitudes and continue for some time in comfort.

It sometimes happens that patients are sent to Colorado for lung trouble, which is suspected by reason of hemoptysis, when examination discloses the difficulty to lie in a narrowed mitral orifice. Gradually failing compensation in any heart lesion finally loads the right ventricle with residual blood, and strains its thin wall and marks the beginning of the end. When this stage is reached and paralysis of the right heart is approached, it is probable that it were much better

for a patient to be in a low rather than in a high altitude. But, as Babcock suggests, in any compensated valvular heart lesion except mitral stenosis there is no evidence that moderately high altitudes are contraindicated. On the contrary, it is not improbable that, under such conditions, the increased load thrown upon the right heart may lead to a salutary hypertrophy which, combined with a lowered arterial resistance, may be best adapted to maintain the physiologic efficiency of the organ. Yet brilliant examples of the benefits derived from climatic change may be seen in cases whose pathology seems primarily dependent on functional disorder of the circulation. This is illustrated by the example of a lady, aged sixty-four, whose heart is somewhat dilated, but without valvular lesion. Her radial arteries are not markedly thick, but the pulse tension, judged by the touch, is usually high, the systolic blood-pressure ranging from 140 to 160 mm. Hg. She is subject to occasional attacks, marked by cough, indicative of pulmonary congestion, during which pure blood may be expectorated. At the same time the urine becomes much reduced in quantity and loaded with urates; it never contains albumin or casts. Coincidentally, there is great depression of spirits, and, conversely, in this case and in similar ones, mental worry and anxiety add gravely to the physical disability. Removal from Denver to sea-level works an extraordinary amelioration of symptoms, and the patient returns after a month or two to fall very gradually into the same train of troubles. It appears that the disorder is initiated by weakness of the left ventricle, leading to accumulation of residual blood within it, followed by a damming back of the venous circulation and passive congestion of the viscera. It is obvious that the chain of events could be started by weakness of the left ventricle, disclosed either by increased ratio of arterial resistance or excessive inflow of blood from the right heart. The greater the elevation above the sea, the more marked is the difference between cardiac action in a state of exercise as compared with rest. The symptoms of mountain sickness are sometimes precipitated merely by physical exertion. It would not be prudent to send to a high altitude a person with an organically weak heart, at least without warning as to the dangers of overexercise.

The treatment of chronic heart diseases by means of saline carbonated baths, as practised at Nauheim, is vaunted in many separate treatises. It is worth noting that Dr. James Mackenzie, in his recent work on Diseases of the Heart, 1908, discredits the assumed virtues of the method.

Dr. E. J. A. Rogers, of Denver, who has extensively applied suggestion therapeutics in his medical practice, in a verbal communication expresses the opinion that this field of treatment offers in many cases of heart disease the most efficient remedial influence within his experience.

Chemical improvement in cardiac metabolism and mechanical increase in the amplitude of cardiac contraction are the interdependent achievements sought by the therapeutist. Clear as is the goal in

view, the way to it has many turns and partings to lead the seeker astray.

There is good reason to believe that at even moderately high altitudes pulmonary edema is apt to be precipitated by injudicious exercise in persons who have chronic pulmonary tuberculosis, especially when they are unacclimatized and when afflicted with vascular fibrosis. The catastrophe is very fatal.

Arteriosclerosis.—It is usually taken for granted that all forms of arterial degeneration, including fibrosis, contraindicate a visit to or a residence in high altitudes. The fact that physical exercise, especially in the unacclimated, provokes proportionately greater activity of the circulation in high altitudes makes it probable that vascular strain would be increased under these conditions. But there seems no reason in theory or experience why, leading a quiet life, a person with stiffened arteries may not safely venture to an elevation of 5000 to 7000 feet. Babcock's observations lead him to the conclusion that "Patients . . . with arteriosclerosis, with or without myocardial changes, may endure low atmospheric pressure without injury." I have been astonished to observe aged men and women with arteries stiff, tortuous, and nodulated, living year after year in perfect comfort at a mile or more above sea-level. Experimental observations which show a diminution of arterial blood-pressure with altitude, of course, point to a reduction rather than an increase of vascular strain under these conditions. No comparative observations are known to the writer which would throw light on the relation of climate to disease of the veins. It would seem that venous thrombosis would be favored or restrained by conditions leading to stasis or rapidity of the venous circulation, respectively. A cord-like consistency of the superficial veins is common among patients seen in hospital practice in Denver.

Pneumonia.—The pneumonias, which are so peculiarly associated with certain conditions of season and weather, would seem to be especially fitted for climatic prophylaxis; but, aside from the varied efficiency of sanitary administration, local influences seem to have little bearing on their occurrence. It might be expected that a greater fatality would attend the disease in high than in low altitudes. But the statements of physicians living at Leadville, Colorado (altitude, 10,200 feet), and hospital statistics from Denver, compared with those from eastern institutions, do not bear out this view. Kieffer[50] finds that at Fort Russell, Wyoming (altitude, 6195 feet), the 18 deaths from pneumonia which occurred among soldiers during thirty-six years from a sick-list of 26,569 represented a mortality of 14.63 per cent., which was about 1 per cent. lower than in the army at large for the same period from the same disease. Dr. J. N. Hall,* of Denver, collating an exceptionally large experience as a consultant, concludes that "the mortality of acute pneumonia is not materially affected by altitude until one passes beyond an elevation of 6000 or 7000 feet." It is in the period of convalescence from pneumonia that the question

* Trans. Amer. Climatol. Assoc., 1909.

of climatic change is apt to be considered. I should prefer in such a case some dry, sunny spot near sea-level, with cheerful company. Convalescence from these disorders proceeds rapidly at high altitudes when the heart is sound, but convalescents seeking high elevations must use scrupulous care not to overexercise. When the heart has quite recovered after an attack of simple or complicated **pleurisy,** a sojourn in high altitudes may be of great utility, but even then adhesions, especially if they involve the pericardium, may cause a rapid pulse and embarrassed heart-beat, which indicate a lower level. Some of the most satisfactory results of the Colorado climate are seen in cases of pleurisy which may reasonably be suspected to be of tuberculous origin.

The pathologic trinity of **emphysema, chronic bronchitis,** and **asthma** is frequently seen illustrated in the hospitals of Denver, particularly in persons past middle age who have been engaged in hard manual labor. It is a most discouraging combination from a therapeutic standpoint, at least in high altitudes. The *asthmatic* symptoms may manifest every gradation in relative prominence, and the seizures are sometimes desperately poignant. Strange to say, uncomplicated "bronchial" asthma is apt to find complete relief in high altitudes, and probably many people walk in comfort the streets of Denver who dare not, for fear of an attack, travel as far east as the Missouri River. Persons suffering either from *chronic bronchitis* or *emphysema* will probably fare best in a moderately warm, moist, and equable climate, such as is found in southern California or in the Southern States.

Hay-fever is a pathologic free-lance. In his work on Climatology Solly quotes an excellent description of the distribution of the disorder in the United States. People who suffer from the catarrh in the neighborhood of Denver often find relief through a sojourn in the mountains.

Nasal and pharyngeal catarrhs, improperly so called, are apt to disturb newcomers in high altitudes. The condition is marked by increased congestion with deficient secretion of the mucous membranes, and rights itself as the subject becomes acclimated. Dr. J. Fletcher Ingalls,[39] of Chicago, recommends low humidity and moderate elevation above the sea for certain disorders of the nose and throat.

Rheumatism.—Difficulty in understanding the meaning of this term as commonly employed makes it impossible to collate medical experience as to its climatic relations. Hirsch[45] says: "The distribution of rheumatism, taken as a whole, extends uniformly over the entire globe." The old view of Cullen that the disorder was precipitated by "chill" does not invalidate the theory of its infectivity. Hirsch's European statistics indicate that the disease is most frequent in winter and spring, and least so in autumn; cold combined with dampness "seems to give the environment most favorable to precipitating the disorder." According to Osler,[51] "In London the cases reach the maximum in the months of September and October."

Rheumatic pains, articular and otherwise, are extremely common in

Colorado. But the writer's individual experience would indicate that the more sthenic forms of acute articular rheumatism are relatively rare. On the other hand, it is sadly common to find in children signs of valvular lesions when it is impossible to get a definite history of a preceding rheumatic attack. Pains in the muscles, in the connective tissues, and, apparently, in the serous membranes, which yield to treatment by salicylates, are frequently encountered in medical practice in Denver. *Rheumatoid arthritis* here, as elsewhere, claims an increasing proportion of subjects who were formerly classed as "rheumatic."

Gout.—Disorders in metabolism resulting in "lithemia" or "irregular gout" appear to be very common in Colorado. Balfour[52] states, and quotes Gairdner in confirmation, that "'venous congestion,' as it is usually termed, has been recognized by all physicians since the day of Galen as the first condition essential to the formation of the gouty diathesis." In view of the evidence offered above as to the influence of high altitudes in raising venous blood-pressure, there is satisfactory harmony between facts and theory in this subject.

Digestive Disorders.—Not climate, but food, drink, and habits of life are the responsible factors in preventable disorders of the digestive tract, though judicious change of climate may have a curative effect. The late Dr. W. W. Johnston[53] was of the opinion that patients suffering from chronic diarrhea, including mucous colitis, were greatly benefited by a sojourn in the mountains of the eastern States—in the north in summer and the south in winter. Only mild forms of the trouble did well on the seashore, and then only in warm weather.

Skin Diseases.—That climate markedly affects the physiologic activity of the skin is a matter of common knowledge, but detailed scientific observations on the subject seem to be very few in number. Eskridge[54] found, with the use of the surface thermometer, that "the normal head temperature in Colorado is about half a degree (F.) higher than in Philadelphia. The exposed skin tends to become dry and parched in high altitudes, and it seems probable that some of the nervous and metabolic effects of such regions have their origin in skin changes. Authors are prone to write confidently of the increased loss of water in the form of insensible perspiration in elevated climates, but facts seem to be wanting."

Dr. L. D. Bulkley[32] voices the common experience that cases of *eczema* do badly on the seashore, and that the disease is aggravated by cold, damp weather. *Acne* is made worse on the coast, and is apt to improve at high, dry, inland stations. *Psoriasis* needs a warm climate. Dr. J. M. Blaine, who has had a wide experience with skin diseases in Denver, thinks that in this locality those skin diseases do worst which depend upon nervous derangement. The climate is well suited to cases of lupus.

The Nervous System and its Diseases.—Climates may affect the nervous system either directly or indirectly through their influence

on metabolism in its widest sense. Using the rather indefinite terms in vogue, climates may be *relaxing*, *sedative*, or *stimulating* in their influence. When nutrition is improved and a state of well-being secured, the qualifying term *tonic* may be added. Thus, warm, moist coasts or islands are sedative to relaxing. On ocean voyages or cooler coasts the prevailing influence is tonic-sedative. Inland places of low altitude are usually simply tonic in effect. Elevated inland regions are stimulating-tonic or simply stimulating.

That brilliant clinician and phenomenon of intellectual vigor, the late Dr. J. T. Eskridge, lived in Colorado for many years and made a special study of the climatic relations of nervous phenomena. Eskridge is careful to distinguish the nervous influences of high altitudes according as they occur in "acclimated" or "unacclimated" persons. "For nine out of every ten healthy persons who come to Colorado and do not almost immediately begin to overexercise at the higher altitude no unpleasant effects are produced."[56] "If physical exercise be freely and indiscriminately indulged in, the person soon becomes restless. To keep quiet then is difficult and irksome, but to continue the exercise increases the nervousness and restlessness. The legs feel tired and heavy, and numb and tingling sensations, with pains in the joints, are often experienced. The muscles become sore and painful, and cramping of the calf muscles is suffered from at night. Sleeplessness follows, and this, with the restlessness, makes the night almost unendurable. The severer symptoms are experienced only by the nervous and unacclimated persons who disregard advice and exercise too much." "For persons advanced in years, and for nearly all invalids, there is but one rule—keep comparatively quiet at first, and, when moderate exercise is begun, always stop short of the point of decided fatigue."[53] "For the majority of persons, especially for the consumptive invalids, sleep is more easily obtained, more continuous, and more refreshing in Colorado than in the Eastern States."[54] Eskridge thought that cases of insomnia from venous stasis or passive hyperemia of the brain sleep well in Colorado, but that insomnia caused by organic cerebral disease or active hyperemia of the brain is made worse. "The general impression that a prolonged residence in Colorado has a tendency to produce simple nervousness and finally sleeplessness, I think, is correct. At least, I have advised many to take a trip to a low altitude for a few weeks once a year. . . These periods of relaxation have been especially advised for the overworked, mentally or physically, and for the nervous or hysterical."[56] According to Eskridge, persons who are nervous as a result of malnutrition or overwork do well in Colorado because of improvement in the general condition, but those of inherent nervous temperaments do badly, and some who are not considered nervous become so after prolonged residence in Colorado. "Hysterical subjects do better at sea-level than in Colorado, unless the hysterical manifestations are due to depressed states of health that are relieved by a residence in Colorado. . . The same may be said of *neurasthenic* subjects,

except that some of the causes of neurasthenia are more commonly removed by a residence in Colorado than are those of hysteria. . . The ideal life for those afflicted with migraine is a frequent change of climate, from Colorado to sea-level, living at least two-thirds of the time at low altitudes.

"Choreic patients should not be sent by choice to Colorado for treatment; . . . however, they can be cured in about as short a time here as they can at sea-level, provided the precaution is taken to keep the patients in bed until all violent movements have subsided. . . . I have been unable to observe any marked difference in the frequency, course, and results of *organic disease of the nervous system* here from what I found to hold in Philadelphia, in which city I practised for nearly ten years before being forced to seek the Colorado climate. . . I must not fail to add that for persons with rather an unstable and highly nervous organization, there is greater danger of contracting drug or alcoholic habit at high altitude than is the case at sea-level."[56]

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ARTIFICIAL AËROTHERAPY

By Henry Sewall, M.D.

It is not strange that air, modified in one or another of its physical properties, should have early become recognized as a therapeutic agent in disease. Thus has arisen the art of aërotherapeutics, which would seem to deserve careful development, though the claims of its partizans have frequently failed of demonstration because founded on erroneous theories of the physiologic physics of the body. Only a brief outline of the subject can here be presented.*

The atmosphere may be artificially modified by changing its—(*a*) *Temperature;* (*b*) *density;* (*c*) *composition.* Under the latter head may be included its functions as a vehicle for foreign substances, as powders and sprays. More than one of these properties may be simultaneously varied.

THE USE OF AIR IN THE APPLICATION OF HEAT AND COLD

The general relations of air-temperature to the progress of certain diseases has already been noted in the section on Climatology.

Temperature is one of the most important variables entering into the complex action of climate on life. *Heated air*, either moist or dry, as applied to the exterior of the body, is treated fully in another section. The *hot-air bath* as a sudorifacient is an indispensable aid to the physician. The temperatures that can be borne locally without injury, as in the "baking" of a diseased joint, are extraordinary. A limb is frequently inclosed for half an hour, with good effect, in a chamber heated to 300° and even to 400° F. A striking example of therapeutic misdirection was furnished some years ago in the exploitation of hot-air inhalations in the treatment of laryngeal and pulmonary tuberculosis. Relying on the known bactericidal effect of heat, it was sought to apply this agent by inhalation directly to the seat of disease. That nothing useful was to be expected from the method became clear when it was demonstrated that the inhaled air lost its excess of heat, through evaporation of moisture, in the upper air-passages. In one experiment, when air heated to 428° F. entered the mouth, the temperature of the parenchyma of the lung

*The reader is referred especially to the excellent monograph of Tissier, forming Volume X of S. Solis Cohen's System of Physiologic Therapeutics, 1903; to J. Solis Cohen's Inhalation in the Treatment of Disease, 1876; and to the essay on Artificial Aërotherapeutics by C. T. Williams in Volume I of Allbutt's System of Medicine, 1896; second edition, 1905.

after fifteen minutes did not rise above 104° F., and that in a tuberculous patient. Superheated air has been employed with success in the local treatment of various affections of the ear, nose, pharynx, and larynx. The power of the upper respiratory passages to cool hot air is no more extraordinary than their ability to raise the temperature of a cold current.

THE THERAPEUTIC USES OF ARTIFICIALLY CONDENSED OR RAREFIED AIR

The estimation of therapeutic results from the operation of such methods is especially liable to be complicated by mental suggestion. Much of the investigation along the line of aërotherapy seems to have been warped by preconceived notions. In certain forms of disease, as in emphysema and chronic bronchitis, evidence is strong as to the specific virtues of modified air-pressure, and in others, as chronic heart diseases, it is most desirable that the effect of the treatment be submitted to a renewed and critical investigation.

Air may be employed therapeutically either condensed or rarefied. The whole body may be surrounded by the air-bath, subjecting the skin and the lungs to the same pressure, or the air breathed may be denser or rarer than that surrounding the body.

The gases throughout the living body are at the same tension as those in the surrounding medium. At sea-level this is represented by the pressure of a mercury column approximating 760 mm., or about 30 inches high. When the air-pressure is changed, the tension of the gases dissolved in the fluids of the body gradually becomes uniform with it. The physiologic and pathologic effects of rapid changes in barometric pressure are due to disturbances arising in the adjustment of internal to external pressure. There is apparently no limit to the pressure which can be borne by the surface of an animal provided the anatomic structure will permit its uniform internal distribution. Certain simple aquatic animals live at a depth of 4000 meters of water, representing a pressure of 400 atmospheres. Water, with its contained gas, at this pressure must find free passage between the living molecules. In "caissons," air-chambers used in subaquatic engineering, men have been able to work with safety in air at a pressure of nearly 4½ atmospheres. Marked physiologic disturbances and even illness or death may result from such exposure. The morbid symptoms depend upon a too rapid compression or, especially, decompression of the atmosphere. The danger also increases with the duration of compression. It is also not improbable, as held by Lorrain Smith,* that the known effects of oxygen at very high tensions in producing pulmonary inflammation may play a part. The pathologic effects of injudicious employment of high pressures are so constant that they have been grouped and distinguished under the name of "caisson disease." "These accidents (of decompression) consist

*Jour. Physiol., vol. xxiv.

in an intense *pruritus;* the appearance of *muscular tremors; swelling of the joints; paralyses*, often unilateral, and chiefly paraplegic; and sometimes *sudden death*."* Epistaxis and hemoptysis are common effects, and postmortem examination is apt to disclose hemorrhages within the neural canal. The most probable explanation of these effects ascribes them to sudden liberation of gases within the blood, as the external tension is too suddenly decreased.† For therapeutic purposes the condensation of air is, of course, carried to a much lower degree. As a rule, the addition of not more than $\frac{2}{5}$ of an atmosphere is employed, and $+\frac{2}{3}$ of an atmosphere, an addition of 10 pounds to the square inch, is seldom exceeded.

The condensed-air bath is taken in a pneumatic cabinet, an air-tight chamber connected with a power engine, by means of which the barometric pressure within the inclosure may be raised to any desired level, and at the same time the air can be renewed for ventilation. The expense involved in the employment of such apparatus interdicts its general use, but in the larger medical centers of Europe the compressed-air cabinet, some forms being large enough to hold several people at once, is a familiar feature. Two hours is a common period for the exposure, half an hour being occupied in attaining the maximum pressure, one hour in maintaining it, and half an hour in abating it. Various modifications of physiologic functions attend the administration of the condensed-air bath in normal individuals. The subject at first experiences an uncomfortable sensation behind the fauces and pain in the ears, which are relieved by swallowing. The respirations decrease in frequency, and the phase of expiration becomes relatively prolonged; the depth of respiration is considerably increased, and there tends to become a permanent increase of vital capacity. The sphygmograph shows a lowering of the primary and dicrotic waves, and the pulse-rate is diminished more or less obviously during the sitting. "The pressure is exerted more on the capillaries and superficial veins than on the deeper veins and arteries, and its tendency would be to reduce pressure on the right side of the heart, and to increase it on the left. . . The introduction of a larger amount of oxygen causes greater absorption by the lungs, and leads to further oxidation and tissue change, this being proved by the bright color of the blood seen during bleeding in the bath, by increase in the carbonic acid exhaled from the lungs, and of urea excreted by the kidneys. Muscular power is augmented, appetite generally improves, and weight is almost invariably gained. The temperature is not materially affected."‡

It may be suspected that symptoms such as described are largely due to mental suggestion. Leonard Hill§ declares that oxygen inhalation cannot be used as a therapeutic agent to increase metabolism.

* Tissier, *op. cit.*, p. 68.
† *Cf.* Leonard Hill, Recent Advances in Physiology and Biochemistry, 1906.
‡ C. T. Williams, *Aërotherapeutics*, 1894, p. 104.
§ Recent Advances in Physiology and Biochemistry, 1906, p. 237.

He quotes Pflüger to the effect that "oxygen tensions between 11 per cent. and 94 per cent. of an atmosphere have no influence on the rate of metabolism. Within these limits the cell rules its own metabolism." These statements appear at first glance to be opposed to the conclusions reached by Hill himself,* in conjunction with Flack, in experiments on the influence of oxygen on athletes. These authors found that after oxygen inhalations more prolonged and powerful exertions could be made with less functional disturbance than under ordinary circumstances; and also that the dyspnea and exhaustion after muscular effort were quickly relieved by the same means. Increased ventilation of the lungs by forced breathing had somewhat similar effect on the efficiency of muscular effort.

The clinician who has witnessed the greedy grasp of the oxygen-bearing tube by certain patients in the throes of dyspnea—as in cases of pulmonary edema—is sufficiently convinced of the therapeutic force of the gas. Huggard† draws attention to the clinical experience that whereas oxygen inhalations give remarkable relief in dyspnea resulting from obstruction of the bronchial tubes or diminution of the aërating surface of the lungs, it affords remarkably little relief in cardiac dyspnea. This suggests the shrewd observation of Lees‡ that cardiac dyspnea is due to a reflex resulting from failure of the right ventricle.

Diseased Conditions Treated in the Condensed-air Bath.—*Asthma.*—Patients who suffer from bronchial asthma are said to be frequently permanently relieved by a course of treatment in the condensed-air bath. According to Williams,§ "The effect on the paroxysm is immediate and wonderfully efficacious—in fact, more so than any medicines." The use of compressed air in this connection is especially interesting in view of the fact that many asthmatics find a continuous residence in *high altitudes* necessary to subdue their disorder.

Emphysema.—Observers, for the most part, agree in the extraordinary statement that many cases of pulmonary emphysema are relieved both as to the functional disorder and the anatomic derangement. The appropriate cases are those in which pulmonary congestion and catarrh are marked features; in which, in fact, the vesicular distention has not led to permanent tissue changes.

The treatment seems to reduce congestion, relieve circulatory obstruction, and facilitate gas exchange. No permanent benefit, if any, is to be expected when the air-cells have completely lost their elasticity. Cases of *chlorosis* and *secondary anemia* have been found to benefit by the bath. The attempt to treat *pulmonary tuberculosis* by this or other cabinet methods has not developed encouraging results. *The condensed air-bath is said to be contraindicated*

* L. Hill and M. Flack, Jour. of Physiology, vol. xxxviii, 1909, p. xxviii; Brit. Med. Jour., 1908, vol. ii, pp. 499, 967.
† *Loc. cit.*, p. 137.
‡ Visceral Inflammation, 1904, p. 189. § *Op. cit.*, p. 105.

in all forms of *capillary bronchitis;* in *advanced tuberculous lesions*, especially when there is a tendency to *hemoptysis;* in *mitral stenosis*, and in any *degeneration* of the *myocardium;* in conditions, such as *ascites*, which prevent free descent of the diaphragm.

The use, in a cabinet, of *rarefied air* has found little or no therapeutic application. The physiologic and therapeutic effects of low barometric pressures have already been discussed in the article on climatology. It must, however, be borne in mind that barometric pressure alone forms but one of many variables constituting the resultant climate.

Differential Pneumotherapy.—In the apparatus hitherto considered, air-pressure upon the interior of the lungs and the surface of the body has been identical. It is obviously possible for a person to breathe into a reservoir of either compressed or rarefied air, by means of a mask fitted to the face, while the body, as a whole, remains under ordinary atmospheric pressure; or a person may enter an air-tight cabinet in which the pressure may be increased or decreased by means of a bellows, and still breathe air at ordinary pressure by applying the lips to a tube traversing the wall of the cabinet. Moreover, by a proper arrangement of valves, the pneumatic apparatus may be constructed so that the breath is exhaled into air which is, at pleasure, either denser or rarer than that inhaled.

These various methods applied in disease constitute "differential pneumotherapy," a term of obvious origin. A great number of instruments, of every degree of portability and costliness, have been devised for accomplishing these purposes. The very simplest of these devices is illustrated by the familiar breathing-tubes of Howe and others, which may be carried in the vest-pocket. The air may be inhaled fairly freely through the tube held between the lips, but exhalation is retarded by a simple valve in the instrument which compels the air to escape through a minute aperture. Thus, at inspiration the air within the lungs is somewhat rarefied, and at expiration decidedly compressed. The breathing-tube admits of no pulmonary exercise that cannot be achieved without its aid. There is no doubt, however, that the apparatus is a valuable aid to suggestive therapeutics, and that ventilation of the lungs is apt to be voluntarily more thorough under its use. Medicated and soothing vapors may be administered through the tube if modified, as in the instruments of Cohen and Denison. The writer has learned to fear the use of the device in cases prone to hemoptysis.

Waldenburg was the principal pioneer in the exploitation of the methods of pneumatic differentiation in therapeutics. His apparatus, described in 1873, consisted of one cylinder, movable within another which was filled with water, on the principle of the gasometer, whereby compressed or rarefied air could be supplied for respiration. His enthusiastic claims for the therapeutic virtues of pneumotherapy, and his detailed descriptions of the physiologic effects of pneumatic differentiation, brought the method into familiar use for some years;

but the adverse conclusions of other investigators led to the, perhaps, unfortunate result that the procedure has become well-nigh a lost art in the treatment of disease. The monograph of Tissier contains a historic and critical review of the subject. The difficulties of scientific exploration, as well as of therapeutic application, in this field are greatly enhanced by the psychic disturbances incident to the unnatural method of respiring through a mask. Of the numerous portable instruments used for the purpose of modifying the pressure of air supplied to the lungs, those devised by Hogyes and by Dupont, on the principle of the Bunsen filter-pump, seem to be best adapted to their purpose. By means of flowing water air within one cylinder is condensed, and in another rarefied, to a known degree for any desired time. With a mask, connected by tubes with the apparatus, over the mouth, and with an appropriate system of valves, inspiration of condensed air, with expiration into normal or rarefied air, may be carried on at pleasure. In the United States differential air-pressures have been frequently applied through the use of the pneumatic cabinet of Williams and Ketcham, introduced in 1855, which is less expensive and cumbersome than the form already described as employed in Europe for the administration of condensed air. The cabinet is large enough to hold seated a patient who breathes the external air at ordinary pressure through a tube, sealed through the wall of the chamber, to which the mouth is applied. By means of a bellows the air within the cabinet may be either condensed or rarefied. When the latter condition is maintained, the subject breathes relatively condensed air, while the surface of his body is under lowered barometric pressure. The mechanical effect of such atmospheric differentiation must resemble in kind the extraordinary results of the cupping-glass, except that the *vis à tergo* is limited solely to the surface of the lungs. According to Quimby,* pneumatic differentiation through use of the cabinet is the ideal method of treating cardiac degeneration, and the various valvular heart lesions, excepting mitral stenosis. In this author's practice the patient, seated in the cabinet the air-pressure in which is reduced, say, two inches of mercury, or one pound to the square inch, inspires slowly through the tube the outside air at barometric pressure. At the end of inspiration a stop-cock is turned, severing communication with the outside air; the patient removes the tube from the mouth and breathes the rarefied air of the cabinet. The effect of inspiration under these conditions is to draw the blood into the peripheral systemic vessels, to deplete the lungs, mechanically support the heart, and facilitate the emptying of the left ventricle. It is argued that respiration of the attenuated air of the cabinet, on removing the tube from the mouth, leads to relative hyperemia of the lungs and filling of the heart. Successive inspirations again deplete the lungs and heart. The sittings last from ten to twenty minutes daily, or as required.

Thus there are two general methods of producing pneumatic

* Jour. Amer. Med. Assoc., March 15, 1902; also, Trans. Amer. Climat. Assoc., 1904.

differentiation: one by means of the apparatus of Waldenburg and others, which supplies compressed or rarefied air to the lungs, the surface of the body remaining under normal barometric pressure, and the other by the pneumatic cabinet of Williams and Ketcham, in which, while pressure within the lungs may remain barometric, that upon the body surface may be varied. Although an identical abnormal ratio of intrapulmonary to surface pressure may be produced by the two methods, it does not follow that the physiologic results are the same in the two cases. Thus Quimby allows his patient in the pneumatic cabinet to breathe at an ordinary pressure, while the air-pressure within the apparatus is reduced one or two inches of mercury, representing $\frac{1}{30}$ to $\frac{1}{15}$ of an atmosphere, or the lowering of pressure to the square inch of $\frac{1}{2}$ to 1 pound. With the use of the other form of apparatus it is not customary to administer condensed air with pressure in excess of $\frac{1}{80}$ to $\frac{1}{40}$ of an atmosphere. Indeed, Grehant found that compressed air with an excess of pressure of 6 centimeters of mercury (2.4 inches) supplied to the lungs of a dog caused arrest of the animal's heart in a few seconds.

E. Kuhn* has lately devised a "suction mask" which is closely fitted over nose and mouth, and is provided with an arrangement by means of which the entrance of air is more or less impeded, while its expulsion is not obstructed. Breathing through the mask causes hyperemia of the lungs and some overfilling of the heart. Great claims are made for the efficiency of the apparatus in the treatment of a large number of disorders, including pulmonary tuberculosis.

Therapeutic Uses of Differential Pressure Methods.—That distressing pathologic trinity, *emphysema-bronchitis-asthma*, which is so resistant to ordinary remedial measures, seems often to yield temporarily, and even permanently, to the inhalation of compressed air, especially if combined with expiration into rarefied air. So, also, *bronchial asthma*, *emphysema dependent upon bronchitis*, and *chronic bronchitis* itself are said to be sometimes wonderfully relieved by the method. Authors advise the inhalation of condensed air to promote expansion of the lung after *thoracentesis*. A familiar means of attempting to accomplish the same object is for the patient to expel air from the lungs against some positive resistance, such as is encountered in exhaling through a tube whose free end is plunged beneath the surface of water, or in driving, by forcible expiration, the water from one to another of two bottles properly connected by glass and rubber tubing. Inspiration of condensed and, at times, expiration into rarefied, air is advised for the breaking up of pleural adhesions in their early stages. The results of the treatment in *pulmonary tuberculosis* have not sustained early anticipations. But when the disease is but slightly advanced and not active, and when there is no tendency to hemoptysis, good results are said to follow the careful administration of air condensed to an excess of barometric pressure of $\frac{1}{150}$ to $\frac{1}{50}$ or even

* Deutsch. med. Wochensch., xvi, 1907. Münch. med. Wochensch., liv, 1907.

gradually increased to $\frac{1}{30}$ of an atmosphere. In addition, expiration into slightly rarefied air may be practised.

The diversity of views held by workers in this field as to the influence of the method on the *circulation* sufficiently indicates the necessity of experimental revision of the whole subject.

THE THERAPEUTIC USE OF AIR MODIFIED IN COMPOSITION OR INGREDIENTS

Many gases of toxic nature find ready access to the body and may produce disastrous results by acting on or absorption through the lungs. The many attempts to attack even pulmonary disease processes though this avenue, by gases and vapors diffused in the air, have generally failed. Paul Bert discovered the curious fact that when animals breathed air in which the partial pressure of oxygen equaled 3 to 4 atmospheres, convulsions and finally death were produced. Physiologists have conclusively shown that increase of oxygen tension in ordinary air, even to the extent of replacing the air with pure oxygen, causes no decided change in the respiratory process. But J. Lorrain Smith* has shown that when oxygen at a tension considerably higher than 1 atmosphere is breathed (by small animals), it irritates the lungs and produces inflammation. This author holds that absorption of oxygen by the lungs is an active physiologic process.

Oxygen finds an important therapeutic application in most acute conditions of tissue suboxidation. It is, of course, of but temporary aid, but it usually relieves the suffering of dyspnea and frequently helps to tide over an otherwise fatal crisis. Its use has been highly extolled in certain stages of pneumonia. As the dyspnea in this disease is perhaps largely due to a cardiac reflex, the frequent failure of the inhalation to relieve distress is explicable; even so the cyanosis is reduced. No agent is more effective for good in the treatment of the suboxidation of opium-poisoning. The patient who suffers the air-hunger preceding dissolution is apt urgently to demand the gas after once experiencing the relief afforded by it. The main indication for the therapeutic use of oxygen is cyanosis, especially when coupled with dyspnea. The somewhat contradictory experience as to the beneficence of its action may possibly be explained by the occasional failure of the living cells of the pulmonary vesicles to respond to the stimulus which normally excites the process of oxygen absorption.† Gases added to the atmosphere readily penetrate to the lungs and exercise their specific effects. The respiration of pure *carbonic acid*, CO_2, is quickly fatal, but it is said that air containing 25 to 30 per cent. of the gas may be inhaled for a few minutes without ill effect.‡ Carbonic acid in small proportions has been administered as a local sedative in irritable lung affections; the remarkable physiologic action of

* *Loc. cit.*

† *Cf.* Haldane and Smith, Jour. Physiol., 1897, vol. xxii.

‡ *Cf.* Wilson, Amer. Jour. Pharm., 1893.

this agent on other body surfaces would seem to warrant careful investigation of its properties when inhaled. *Carbon monoxid*, CO, a constituent of ordinary illuminating gas and a product of the incomplete combustion of carbon, is extremely poisonous, air containing 2 per cent. by volume being quickly fatal. This is said to be the deadly ingredient in the air of a coal mine after an explosion. An atmosphere containing sulphureted hydrogen, H_2S, in the proportion of 0.4 volume per cent., is said to be toxic. Some years ago this gas was given temporary notoriety in therapeutics by Dr. Bergeon, of Lyons, who advised the treatment of pulmonary tuberculosis by rectal injections of a mixture of H_2S and CO_2, the procedure being based upon the Bernard's discovery that certain gases, poisonous when breathed, might be safely absorbed through the colon and eliminated by the lungs. It is said that *nitrogen*, *hydrogen*, and *carbureted hydrogen* (CH_4) may be inhaled with impunity provided they contain oxygen to the extent of 13 volumes per cent.

Cyanogen, *phosphoreted hydrogen*, *arseniureted hydrogen*, and *antimoniureted hydrogen* are all poisonous through combination with or destruction of hemoglobin.

Certain fumes and gases, as *ammonia*, *bromin*, *chlorin*, *ozone*, *nitrous acid*, *chlorin*, are severe irritants to the respiratory mucous membrane, and may provoke in it such changes as to cause death. *Nitrous oxid*, N_2O, or laughing-gas, the oldest and the safest of the general anesthetics, is familiar as an agent for providing brief periods of anesthesia. Its administration is said to cause considerable elevation of arterial blood-pressure. *Chlorid of ammonium* fumes, generated by the admixture of ammonia and hydrochloric acid, and washed by being passed through water, have been used successfully in the treatment of catarrhs of the upper respiratory passages. The *vapor of iodin* has been strongly indorsed as an inhalant in the treatment of phthisis. *Formaldehyd*, spontaneously evolved from its solution contained in an open vessel, has been advised as a therapeutic antiseptic.

The vapors of certain liquids which are volatile at low temperatures are extensively used, more or less mixed with air, for the production of general anesthesia. Most of them have had but temporary vogue. For the maintenance of prolonged anesthesia ether and chloroform, or their mixtures, are still unrivaled. To secure unconsciousness for short operations, lasting not more than ten minutes, the lately introduced "somnoform," a mixture of ethyl chlorid, methyl chlorid, and ethyl bromid, seems to have special advantages in its quick action and comparative freedom from after-effects.

It would seem a very easy matter to introduce into the lungs finely divided sprays of liquid substances or even the powders of solids, but such is not the case. It requires special training on the part of the patient to really inhale a foreign substance projected into the mouth by an "atomizer," so instinctive is the action of the defensive mechanism of the larynx. The tendency is for the patient

to involuntarily retain the medicine within the buccal cavity, as the smoker does the fumes of his cigar. Even when the spray or powder is injected directly through the glottis, it, for the most part, settles upon the walls of the upper air-passages and fails to reach the smaller tubes. Nevertheless, the condition of pneumonokoniosis is substantial proof that even solid particles, when finely divided and suspended in air breathed for long periods, may penetrate to the finest bronchioles.

A great variety of devices has been employed for the introduction of medicaments to the lungs and respiratory passages. The inhalation of the *fumes* of *burning solids* prepared in the form of cigarets or by impregnating absorbent paper with their solutions has been used with satisfaction in the treatment of asthma, and Trousseau recommended the administration of mercurial fumes produced in this way in cases of syphilitic pharyngitis and laryngitis.

The humidity of the air of a room is easily raised to any degree by heating water in an open vessel, and the moisture itself is soothing and expectorant to the bronchial surfaces. Such moistened air has been advised in most acute affections of the pharynx and larynx.

The addition of medicines, such as terebene, tincture of benzoin, etc., to the steaming water forms a safe and easy method of administration. A favorite and efficient method of inhalation is for the patient to breathe directly the impregnated vapor of hot water contained in a small jar or pitcher; a towel should be folded around the opening of the vessel, and the free margin applied like a mask about the mouth and nose of the patient.

The fumes of volatile fluids, such as creasote, oil of peppermint, etc., can be inhaled without discomfort for indefinite periods when the material is sprinkled upon a gauze or sponge which is inclosed in a perforated metal or wire mask shaped to fit over the nose and mouth, and held in place by a string around the head.

The *atomization* of medicinal fluids may be accomplished either by the aspirating force of a steam jet, whereby the warmth of the applied vapor has a specific effect, or by the projecting force of condensed air at ordinary temperatures. The use of *sprays* or *nebulæ* of medicinal substances dissolved in water or oil has become an indispensable feature of rhinologic and laryngologic practice, and the subject is far too broad to be adequately covered in a brief discussion.

ELECTROTHERAPY

By J. Montgomery Mosher, M.D.

For therapeutic purposes, in medicine and surgery, all forms of electricity are employed. Both electric currents and static electricity are in common use; static, Franklinic, or frictional electricity was at one time much in demand, but was afterward abandoned, and more recently again has been growing in favor.

Electric currents may be produced in a variety of ways, and are available in four forms:

1. The galvanic current, derived from contact, the constant or continuous current.
2. The faradic current, the induced, interrupted, or induction current.
3. Static electricity.
4. High-frequency currents.

The galvanic and faradic currents may be derived from batteries or from dynamos. In cities, the distribution of currents for electric lighting, railways, etc., has become so well-nigh universal that it is frequently practicable, for house and office use, to obtain the currents from mains. Portable batteries, however, are frequently necessary, and cannot yet be supplanted.

ELECTROPHYSICS

Galvanic Electricity
Constant, Continuous Contact Electricity

When two dissimilar metals or chemical elements are placed in a liquid, particularly brine or a weak acid solution, there develops in each element a certain potential energy or tension, and one becomes positively, and the other negatively, electrified. The chemical elements may be arranged in a series with respect to their electric affinity for one another, so that any substance in the series is positive to the other substances toward the negative end of the series, and negative to any substance toward the positive end. Thus, if zinc be brought into relation with iron, the zinc becomes positively, and the iron negatively, electrified, and each to a certain degree. If, however, zinc be brought into relation with copper, the zinc becomes more positively electrified than it was before, and the copper more negatively electrified than was the iron; that is to say, a greater potential difference is manifested by the association of the zinc with the copper than by the association of the zinc with the iron. And also, if iron be

brought in relation with copper, the iron becomes positive, since iron is negative to zinc, but positive to copper.

The difference of potential energy of the chemical elements may be represented by the so-called *electrochemical series*, as follows:

Electronegative end of the series

—

Oxygen
Sulphur
Nitrogen
Chlorin
Iodin
Phosphorus
Carbon
Hydrogen
Gold
Platinum
Silver
Copper
Lead
Iron
Zinc
Sodium
Potassium

+

Electropositive end of the series

The simplest way of producing galvanic electricity is as follows: Plates of two *dissimilar electric-conducting substances*, as, for example, copper and zinc, or carbon and zinc, are placed parallel with each other, but not in contact, in a jar containing brine or an acid solution, and their exposed ends are connected by a conducting body, such as a copper wire. By the contact of the metals with the fluid and with each other through the conducting wire electricity is evolved, so that in one metal positive electricity is produced, and in the other negative electricity. Under these conditions a *closed circuit* is formed, the zinc is slowly dissolved, bubbles of hydrogen appear on the carbon or copper, and the electricity *flows* from one to the other plate. The circuit is then said to be *made;* and unless a complete circuit is made, the current cannot flow. When the connection between the plates is destroyed, no change is seen; the current does not flow, and is said to be *broken;* and the circuit is *open*. Such a simple combination—two disconnected elements immersed in a solution—is called an *open cell*, or an *open simple element*, the word *element* in this relation being used with its electric and not its chemical significance. The plates are also called *elements*, and the fluid is known as the *electrolyte*.

With the completion of the circuit, and through the contact of the metals with the fluid, influences are produced that maintain dif-

ferences of potential in the various parts of the circuit, and a continuous current results. In the cell, or *inner circuit*, the current flows in the direction of the negative element from the positive, or from the zinc to the carbon; and in the wire, or *outer circuit*, from the carbon to the zinc. That part of the circuit from which the positive current enters the connecting wire or leaves the cell is known as the *positive pole* or *anode*, and the element through which it reënters the cell is known as the *negative pole*, or *cathode*. The positive zinc plate thus becomes the negative pole, and the negative carbon or copper plate the positive pole. This property, by which the difference in potential constantly produces a current, is known as the *electromotive force*. The term *electromotive force* (represented by the letters E. M. F., or E) is consequently employed to denote that by which electricity is moved from one place to another. It is not to be confounded with *electric force*, which is the force by which electricity moves matter. Other terms to express electromotive force are *pressure*, *potential*, *difference of potential*, and *voltage*. The amount of the electromotive force depends upon the qualities and relations of the metals and fluids used: the greater the difference in potential between the metals, that is, the farther apart the metals in the electrochemical series, the greater the current. It is not practically dependent upon the size of the plates or their distance from each other in the cell.

Polarization.—If the conditions above described were constant, a permanent electric current would be produced. But the electric current acts chemically upon the fluid. In the closed circuit made by the immersion of zinc and carbon plates in a solution of sulphuric acid bubbles are seen to accumulate upon the carbon plate. This is due to the chemical decomposition represented by the formula—

$$Zn + H_2SO_4 = Zn\ SO_4 + H_2,$$

the bubbles consisting of hydrogen gas. This accumulation of hydrogen gas on the carbon plate opposes resistance to the current of electricity, as gas is a poor conductor of electricity, and also acts as an electropositive surface, interposed between the original similarly positive zinc element and the carbon. This is called *polarization*, and when a cell *gives out* from this cause, it is said to be *polarized*. The best cells are those in which polarization is reduced to a minimum. This is accomplished in three ways: (1) By *mechanical depolarization*, as by keeping the liquids in agitation, or by roughening the surface of the elements so that the bubbles of gas cannot accumulate; (2) by *chemical depolarization*, accomplished by adding to the electrolyte some highly active oxidizing substance, as potassium bichromate, nitric acid, or chlorid of lime, to dissolve the precipitated zinc, or to destroy the hydrogen bubbles in the nascent state; and (3) by *electrochemical depolarization*, in which the elements are immersed, each in its own solution, separated by a porous partition—the so-called *double-fluid cells*.

Types of Cells.—For practical purposes it is necessary to assure

the constancy of the electric cells by preventing polarization. Cells in which this obstruction is overcome by *mechanical* or *chemical* means are known as *single-fluid* cells. In the *Smee cell*, a silver plate covered with platinum as one of the elements gives a rough surface, to which the bubbles of hydrogen do not adhere. The current diminishes rapidly in the Smee cell, and it is not suitable for medical purposes. In bichromate batteries the addition of potassium bichromate to the fluid supplied a highly oxidizing substance for the rapid destruction of the hydrogen bubbles by chemical union. In the Grenet cell the zinc element is arranged for immediate removal from the fluid when not in use, so as to prevent its chemical destruction. This cell furnishes a strong current for a short time. The best single-fluid cell for medical purposes is the Leclanché, in which the carbon element, surrounded by powdered carbon and manganese peroxid, is separated from the zinc by a porous jar, the electrolytic fluid being a strong solution of ammonium chlorid. This cell needs little attention, and is effective for from several months to more than a year. It may then be easily renewed.

The common dry cell now in use is a modification of the Leclanché. The zinc element is shaped as the case, and contains the carbon plate surrounded by a moist magma of manganese binoxid, with, probably, ammonium chlorid. The silver chlorid cell, in which the carbon plate is replaced by a silver wire surrounded by granular silver chlorid, with contact through a sponge or bibulous paper moistened with a solution of ammonium or zinc chlorid, is another neat and serviceable form of dry cell. Dry cells are portable, clean, and easily replaced, or, in the case of the silver cell, renewed.

The double-fluid cells are most constant. Of these, the Daniell cell is the type. The zinc element is immersed in dilute sulphuric acid, contained in a porous pot by which it is separated from the negative plate, of copper, in a solution of copper sulphate. This cell is less durable than the Leclanché, and requires more attention.

The effects of the electric current are: (1) Thermal; (2) magnetic; (3) chemical; (4) physiologic. If the current is made to flow through a thin wire, as in an incandescent lamp, it will heat it; if it passes near a magnetic needle, the needle will be deflected; if it is passed through a susceptible liquid, the liquid will be separated into its chemical constituents; and if the current is passed through the tip of the tongue, tingling and burning sensations or a metallic taste will be experienced. All these properties are directly or indirectly serviceable in the medical uses of electricity.

If several simple elementary cells, such as have been described, be united by binding the dissimilar metals of the consecutive cells, the positive element of one cell with the negative element of the next, a circuit is produced equal in intensity to the sum of the differences of potential or the sum of the electromotive force of the cells in use. This is known as *joining the cells in series*. Such combinations of cells are made for use in medical batteries.

The circuit having been completed, it is possible to introduce in the course of the conducting wire any other conducting body, by intersecting the wire and bringing the cut ends in contact with the conducting body, so that the circuit is continuous through this additional body. The different appliances used in electrotherapeutics, or in electrodiagnosis, as the galvanometer, rheostat, pole-changer or current reverser, electrodes, etc., are thus introduced, and the circuit completed through them.

The human body may be thus interposed. The points of exit and entrance of the current and their distribution in the body depend upon the localities upon which the two halves of the conducting wires are placed, the resistance of the body, etc.

In this application to the body that part of the circuit in which the positive current is applied is known as the positive pole, or anode (the carbon or copper pole), and the other part, through which the positive or plus current flows from the body, is known as the negative pole or cathode. The apparatus for the application of the current to the body, which may assume a great variety of forms, is known as the electrode.

The sum and substance of medical electricity then consist of the simple fact that the human body, entirely or in part, may be included in one way or another in the galvanic or electric current; in other words, that the body or its part may be submitted to the current by means of the electrodes, and a definite strength of current for a greater or less time, with or without changes in intensity or interruptions, may be applied.

Faradic Electricity

The Induced, Interrupted, or Inductive Current

If a coiled wire with ends connected be brought quickly in proximity to a magnet, an electric current is induced in the coil at the moment of approximation. If the coil and the magnet are rapidly separated, a current is again induced in the coil, but flowing in the direction opposite to the current induced upon approximation. Similarly, if a coil of wire through which the galvanic current is flowing be brought quickly into proximity to another closed coil, an electric current is induced in the latter, which moves in the direction opposite to the current of the former; if the first coil be rapidly removed, a new current is induced in the second, whose direction is reversed. The same conditions may be produced by arranging the two coils in juxtaposition, and sending successive currents through the one. With every *make* of the current of the *primary* coil a current in the opposite direction is induced in the *secondary* coil; and with every *break*, a current in the same direction. These *induced* currents are stronger as the primary currents are stronger; as there is more wire in the primary as well as the secondary coil, and the nearer to each other the coils are placed, the strongest possible combination being effected when the secondary completely surrounds the primary coil. When the make and break in the current of the primary coil follow each other rapidly,

a great number of currents in rapid succession follow in opposite directions in the secondary coil. So rapid is the succession that these currents, for practical purposes, have the effect of a continuous current, and are known as the *induction current*, the *induced current*, the *interrupted current*, or *faradic electricity*.

The apparatus for the development of faradic electricity for medical use is known as the *induction apparatus*. The secondary coil surrounds the primary coil and is arranged to a slide in a groove, so that the amount of current may be modified by the degree of approximation. The current flowing from the cell to the primary coil passes through an *interrupter*, consisting of a small magnet attached to a steel spring, by which it is automatically interrupted, its direction alternated, and currents of unequal strength are induced. The strength of the induced current may be perceptibly increased by placing an iron bar or bundle of iron wires, the *core*, inside the primary coil, which becomes magnetic on closure, and is demagnetized on opening of the current.

As with galvanic electricity, so with faradic, conductors may be utilized in different forms of apparatus, and introduced into the circuit. The human body may also be interposed, and thus submitted to the effects of the current. The effect of the opening current is so pronounced that it is permissible to determine the polarity, negative and positive, with reference to this current alone.

The **sinusoidal current** is a combination of the galvanic and the faradic, and has been suggested for use when the muscle response to either faradic or galvanic is extremely weak.

Franklinic Electricity
Frictional, Static, or Tension Electricity

This is the manipulation of electricity known earliest. The ancient Greeks discovered that when amber is rubbed with silk it acquires the property of attracting light bodies, and it is now known that in many bodies electricity may be thus developed by friction. Machines for the development of electricity are of two classes—*frictional* and *inductive*. In the former, a glass cylinder or plate is revolved in contact with a *rubber* of leather or of silk, whence positive electricity accumulates in the glass and negative on the rubber. The latter is *grounded* by a metallic connection with the nearest gas-pipe, and its electricity neutralized. The positive electricity of the glass induces a negative change in an adjacent brass collector, which may be utilized. The Wimshurst is the best type of this machine, in which the discs revolve in opposite directions.

The *induction* or *influence* machines depend upon the principle just stated; their action is complicated, and they are more powerful than the frictional machines. The most popular at present is the Holtz-Toepler, which consists of one or more pairs of glass or ebonite discs revolving in the same direction.

In using static electricity the patient is placed upon an insulated

stool, and connected by a conductor to one of the poles of the machine; thus his body is completely charged with electricity and is virtually constituted one electrode. A metal electrode is attached directly or indirectly to the other pole of the machine, and by bringing this electrode near any desired part, a local action is obtained.

Static electricity is administered as a *breeze*, as *sparks*, as the *water-current*, or as the *faradic induced current*. The patient sits upon an insulated platform, and a pointed electrode is brought toward him, whereupon a sensation as if a breeze blowing over the skin is felt. This sensation may occur with the electrode not more than a yard away, and it becomes stronger as the electrode approaches the patient; it may be appreciated as a feeling of warmth, as if hot water were being poured over the surface, and upon still closer approximation the electricity is discharged as a spark.

For giving sparks a ball electrode is used. This is swung rapidly past the area desired to be reached, and as it approaches a spark, is discharged. Sparks have been described as *indirect* and *direct*, depending upon whether the charge is grounded or poles of the machine are operated through the patient placed upon the insulated platform.

When using the wave or the faradic induced current, it is not necessary to place the patient on the insulated stool.

High-frequency Electricity

In recent years high-frequency currents, according to the methods of d'Arsonval, Oudin, and Tesla, have been exploited. To obtain these currents Leyden jars with an intervening spark-gap, with or without accessory coils, are attached to static machines or induction coils, and from the outer coatings of these jars conducting cords are led to suitable electrodes.

APPARATUS FOR THE MEDICAL USE OF ELECTRICITY

The Galvanic Current.—For medical use the galvanic current is developed in batteries consisting usually of 50 cells. For neatness, convenience, and portability modern batteries are usually supplied with dry cells. These cells may be arranged in series of ten, with a contrivance, known as the *current collector* or *cell selector*, for throwing one or more of the series into the circuit.

For exact control of the amount of the current the rheostat is used. Resistance is opposed to the current in these instruments by graphite, water, or long coils of thin wire, so that greater or smaller amounts may be introduced by a simple mechanism.

For measuring the galvanic current the galvanometer in the form of the milliampèremeter is indispensable, for both diagnostic and therapeutic applications. The needle fluctuates, either horizontally or vertically, over the scale. In some instruments the scale may be changed, giving readings for large current intensities, or for very small, to the fraction of a milliampère. In older milliampèremeters

the needles oscillate before the reading is determined; more recently this objection has been overcome in the instruments made after the pattern of d'Arsonval, so that the intensity is indicated as soon as the current is closed.

Another accessory of great importance is the *current reverser* or *commutator*, which is inclosed in the circuit so as to alter the direction of the current, or to *reverse the poles*, that is, to facilitate the transmission of the current through the body in either direction without removal of the electrodes. The principle of this instrument is that two strips of metal, separated by any non-conducting substance, are so arranged upon a swivel that may be placed alternately in contact with either part of the external circuit. The best known commutators are those of Ruhmkorff, in which the strips of metal are placed upon a vulcanite cylinder; that of Siemens and Halske, modified by Brenner, in which a revolving disc is used; and that of deWatteville, consisting of two crank arms arranged to select either two of three metallic studs. Commutators may be placed midway between the connecting points of the circuit, to break the current, and so serve as *current interrupters*.

To convey the current from the battery to the electrodes fine copper wires, easily coiled, and completely insulated with silk, cotton, or rubber, are used. These wires are four or five feet in length, and arranged with metallic terminals for adjustment in the binding parts of the battery and the electrodes.

For application to the body many forms of electrodes are made. The most serviceable are nickeled brass, covered with chamois skin, absorbent cotton, or a fine sponge. A temporary pad of absorbent cotton is neatest and permits removal for each patient. The electrodes for superficial use are button-shaped or flat, and of various sizes, depending upon the uses to which they are to be put. Erb described several sizes: a *small* or *fine* electrode, one-half inch in diameter, for exactly localizing the current upon a single point, such as a small nerve or muscle motor-point; a *medium-sized* electrode, one inch in diameter, for irritating muscles and larger nerve-trunks, and for use about the head and neck; a *large* electrode, two inches in diameter, for general use; a *very large* electrode, four inches in diameter, when a strong current without too great local action is desired. Electrodes of different sizes may be used at the same time, as in diagnostic testing, when the very large electrode is used as an *indifferent* electrode at a neutral point, such as the nuchal region, sternum, or epigastrium, and a small or medium-sized electrode is used as a differential electrode locally upon the muscle or nerve-points. The differential electrode is supplied with an interrupting mechanism, operated easily by the thumb. A convenient form of indifferent electrode is one of wire gauze, fitted with a pad and strap for securing it in place, thus leaving the operator's hands free. A roller or massage electrode and a wire brush are quite commonly needed. These are used for the concentration of strong currents. Frankl-Hochwart has made a

double roller and double wire brush, the two parts separated by non-conducting gutta-percha, so that both cords may be attached to the same handle. Special electrodes for special purposes are innumerable, as for treatment of the urethra, bladder, uterus, throat, stomach, intestines, larynx, eye, etc.

The selection of the electrode depends upon the effect desired. When it is desired to stimulate a nerve or muscle or to produce a marked local effect in a small area, a small electrode is to be used. When a large amount of electricity is to be introduced without local effect, a large electrode is used. It may readily be appreciated that the concentration of the current in a small area bears direct relation to the pain of the operation. This is due to the differences in density of the current. By *density* is meant the amount of electricity in any given area of the conducting body, and when the current is spread over a large surface, its local effect must be much less than when concentrated at a small point.

The Faradic Current.—The accessories to the faradic battery are the conducting cords and electrodes, such as are used with the galvanic battery. A satisfactory practical instrument for measuring the strength of faradic current used has not been perfected. When galvanic and faradic batteries are constructed in the same case, a *current combiner* should be added to the circuit, so that either current or both may be used at will. DeWatteville's key, on the same principle as his commutator, effects this purpose.

The Franklinic Current.—The accessories to the static machine are an insulated platform, which may be extemporized by placing a chain upon the rubber or glass plates; a set of electrodes, of which five are in common use—single point, multiple point, ball or knob, roller, and crown electrodes (the collection may be made as extensive as the fancy of the operator permits); Leyden jars with attachments, and chains for insulating and grounding.

THERAPEUTIC APPLICATION OF ELECTRICITY

For therapeutic purposes the electric currents are to be applied either generally or locally, in given quantity, strength, and direction. The human body, or any of its parts, is to be regarded as an electric conductor, of greater or less resistance, that is placed in the circuit when the electrodes are in position. As compared with other conductors, in either the internal or external circuit, the body offers by far the greatest resistance, and of the tissues the resistance of the skin is so great that none other need be considered. The tissues may be regarded as salt solutions of different degrees of concentration, and to their moisture is attributable their conductivity. The skin, like other structures, is bathed in fluid, except in its epidermal layer; through this electricity is conveyed by the glands, ducts, and interstices; the resistance is lowest where these are most numerous and highest where they are wanting. Thus, it is difficult to introduce a cur-

rent through the soles or callosities of the hands. These conditions of the skin determine entirely the strength of current needed, which is independent of the distance apart of the electrodes. The resistance of the skin is in part overcome by moisture, for which reason electrodes moistened with warm water or normal salt solution are to be used. Other conditions that influence the conductivity of the epidermis are those relative to sex, age, race, and habits of life, all of which must be taken into consideration. No absolute rule can be given, except that careful applications to determine the toleration must be made with each patient and upon each occasion.

The effects of electricity, used therapeutically, are mental and physical. The mental effects are direct and indirect. As a direct mental effect may be considered the influence upon the patient's thought of the mystery and obscurity in which electric force is enveloped. For centuries this imponderable and invisible agent, having the property of inducing pronounced sensations in the human body, has proved effective in cases in which ignorance has yielded more easily to the rhodomontade of quacks and charlatans than to the sober truths of logic. Indirectly, electricity also affects the mind through whatever physical changes follow its use.

The physical effects of electricity are general and local, and electricity is to be used therapeutically for its general or local effects, or both. The general follows the local effect and is tangible. Whatever subtle or incomprehensible result is attributed to electricity may be regarded as speculative, and largely due to the enthusiasm of the operator. The most visible effects of electric applications are in the responses of the motor and sensory nerves. Muscles may be excited by either electric current, directly and indirectly: directly, when the excitation is of the muscle itself, and indirectly, when the excitation is conveyed to the muscle through its motor nerve. The visible evidence of muscular excitation is a contraction. The character of the contraction differs in health, in certain conditions of disease, and under the application of the various currents. The sensory effects of electric applications are also definite, affecting the tracts for tactile and painful impressions, and the special senses. There may be trophic and vasomotor effects of electricity, but these are open to question. Local and general improvement in nutrition has followed the use of electricity, which must be largely attributed to the beneficial effect of systematized muscular contraction. As to the destruction of tissues by electrolysis, there must remain very serious doubt. The transmission of an electric current through a neoplasm must not be confused with the destruction of the neoplasm by actual cautery induced by electricity.

Certain principles, based upon accurate observations, clinical and anatomic, have been established by the use of electricity upon the nerves and muscles. These have been especially elaborated in the art of electrodiagnosis, but as diagnosis must always precede treatment, so in the use of electricity the diagnostic features must be determined before an intelligent therapeutic plan can be arranged.

When the electric conditions of muscles and nerves are to be determined, certain rules of procedure should be followed.

The patient should be placed in a good light, so that the slightest visible contraction may be seen, and the position of the part under examination should be established with as nearly complete relaxation of the muscles as possible. A sitting posture is best for examining the head, neck, and upper extremities. The upper extremities should rest upon a table or upon the knee of the operator, who may find it convenient to place one foot upon the edge of the patient's chair. Trunk muscles may be examined when the patient is sitting or lying. For the lower extremities a suitable rest may be found with the patient sitting, but the most satisfactory results are obtained with the patient reclining. The group of muscles about the buttock and hip may be advantageously tested while the patient is standing on one foot, supporting himself with the hand upon a table or chair. The operator may stand or sit as occasion requires, and should have an assistant to manipulate the battery, and another, when possible, to record the results of the examination. In examining a child the patient should be familiarized with the electrodes by handling them, and one or two applications may be made before the current is transmitted.

Examination of Muscles.—Muscles should be tested first. Any apparently affected muscle may be selected, and in the event of an abnormal electric response being obtained, the remaining muscles of the same group, and finally the nerve by which they are supplied, should be tested.

The battery being in readiness, the electrodes should be moistened in warm water (a salt solution is rarely necessary and is not advised), and the large "indifferent" electrode should be fastened in place at the nuchal region, over the sternum, or upon the epigastrium. The electrodes should never be pressed together, as is often carelessly done, to remove the superfluous water, nor should they be placed simultaneously in the water used for moistening them, as both of these procedures cause a short circuit, which is very detrimental to the battery.

The steps of the test are as follows: Find the desired motor point by its anatomic localization. Grasping the handle with the thumb on the interrupter, place the testing electrode, well moistened, upon this point, and apply steady, firm pressure, with the current open. Do not remove the electrodes or alter the pressure until the test is completed. In some localities care must be taken that the contraction of a neighboring muscle does not dislodge the electrode, as, for instance, in examining the musculospiral nerve, when a slight deviation to one side or the other brings into action the biceps or the triceps muscle. The test should begin with the negative pole of the faradic current. Increase gradually the strength of the current by approximating the coils or by means of the rheostat or current controller, during successive makes and breaks, with the key of the interrupting handle, until the minimal visible contraction of the muscle

is seen. (The operator should not allow himself to be deceived by a voluntary contraction.) Record the amount of current used and the character of the contraction. Break the current.

Exchange the faradic for the galvanic current by the switch, and place in circuit one or more groups of galvanic cells, the milliampèremeter, and the rheostat. Increase the current gradually by means of the current controller or rheostat, during successive interruptions, as before, until the minimal muscular contraction is seen, when the current is to be kept closed. Record the number of milliampères required for the contraction by the reading of the milliampèremeter. If the application is difficult and the needle oscillates, take quickly the mean reading between the extremes of the oscillations. Note the character of the contraction, whether it is quick and "lightning-like," sluggish, or vermicular and wavy. If this cannot be determined, a stronger contraction must be obtained by increasing the current. *This is the cathodal closure contraction—CCc.*

Break the current. Reverse the poles. Close the current, after an interval of at least five seconds. Increase or decrease the current strength with successive closures until a contraction identical in character with the cathodal closure contraction occurs. Record the reading of the milliampèremeter and the character of the contraction as before. *This is the anodal closure contraction—AnCc or ACc.*

Break the current, after at least five seconds, watching carefully whether or not a contraction occurs at the breaking. If not, increase the current until it is seen. *This is the anodal opening contraction—AnOc or AOc.*

The test will have shown whether the response to the faradic or galvanic current is wanting, the character of the contraction, the predominance of one or the other pole, and the relation of the anodal opening contraction to the anodal closing contraction. If advisable, compare the results with those of similar tests upon the opposite side of the body.

Examination of Nerves.—This is to be conducted in the same way as the examination of muscles. One should note whether all muscles supplied by the nerve contract promptly, or whether some do and others do not.

Interpretation of Results.—If the muscle responds to the faradic current in moderate strength, and the contraction occurs suddenly on closing the current, continues during the flow, and disappears abruptly on the opening, and the minimal cathodal closure in response to the galvanic current is greater than the minimal anodal closure, and the contraction is prompt, the electric conditions are normal, and the test may be transferred to another muscle. If the contraction elicited by the galvanic current is exaggerated or sluggish, or the anodal closure contraction is equal to or greater than the cathodal, some pathologic condition is present, and a complete examination of the nerves and the muscles should be made and recorded.

Variations in Electric Excitability

Variations in electric excitability may be—(*a*) *Quantitative*, in which the strength of the response through the nerve only is affected; (*b*) *qualitative*, in which the responses of the muscles to both currents differ from those of health in form and intensity; and (*c*) *quantitative-qualitative*, in which there are combined changes of response of both classes.

Quantitative Variations.—Quantitative increase of excitability has been observed in moderate degree in fresh hemiplegias, occasionally in the initial stage of locomotor ataxia, and at the beginning of certain peripheral palsies, such as rheumatic facial paralysis and pressure paralysis of the musculospiral nerve. In these cases the symptom is transient and unimportant.

Increased excitability is pathognomonic of tetany (*Erb's phenomenon*). Marked quantitative increase of excitability of the nerves, in which the muscles may or may not participate, is found in response to both galvanic and faradic currents, and the contraction may follow a galvanic current derived from one cell (one milliampère or two milliampères). The minimal contraction occurs with the closing or opening of the current at the anode, which predominates over the cathode, and this disease affords the only instance in man of anodal opening tetanus. The contraction may persist after the current is broken. The diagnostic value of Erb's phenomenon lies in the differentiation of tetany from certain simulating conditions, especially spastic states of the extremities in hysteria.

Decrease in electric excitability may be quantitative or qualitative. Quantitative decrease occurs in conditions inhibiting the activity of muscles or nerves, without the presence of organic changes. Any form of paralysis or paresis due to lesions of the central neuron, or to lesions of the peripheral neuron without degeneration, may be followed by quantitative diminution of electric excitability.

In cerebral palsies simple quantitative diminution of excitability may occur, but it is not common and has no diagnostic significance. The same is true of diseases of the brain stem, the peduncles, pons, and medulla, in which lie the nuclei of the motor cranial nerves; and in diffuse or system diseases of the spinal cord not invading acutely the trophic cells of the anterior horns. When the lower trophic centers are involved in destructive lesions, the quantitative changes are associated with qualitative changes, described as the reaction of degeneration. The appearance of qualitative changes, in connection with quantitative, indicates degenerative atrophy, which makes the prognosis more unfavorable.

The peripheral nervous diseases accompanied by simple quantitative decrease in electric excitability may be included under the general term "atrophies of disuse." The affections predisposing to these are joint lesions, "arthritic palsies," and traumatic conditions, as the

temporary palsies following dislocations, and pressure from bandages and splints, as Volkmann's contracture.

Muscular diseases are occasionally accompanied by simple diminution of electric excitability, such as the muscular dystrophies, the juvenile and infantile forms of muscular atrophy, pseudohypertrophy, and occupation atrophies. Simple diminution has also been observed in myositis, as in trichinosis.

Qualitative variations in electric excitability occur only in association with quantitative changes, giving rise to—

Quantitative-qualitative variations in electric excitability. These are: (1) The reaction of degeneration; (2) the myotonic reaction; (3) the myasthenic reaction; (4) the myoclonic contraction; and (5) the neurotonic reaction.

The reaction of degeneration is an abnormal response of the muscle to the galvanic current, characterized by a sluggish, wavy, or vermicular contraction, which shows a tendency to persist after the current is withdrawn, instead of by the lightning-like, sudden contraction which occurs in health immediately upon closing the circuit. This form of contraction is the "modal change," and is usually associated with other abnormalities of electric reaction in the nerve and muscle, known respectively as the "quantitative change," the "qualitative change," and the "polar change."

The "quantitative change" consists of loss of response through the nerve to both the faradic and galvanic currents.

The "qualitative change" consists of loss of response by the muscle to the faradic current, and increased activity of response to the galvanic current, so that a very small current elicits a contraction.

The "polar change" consists of reversal of the normal formula of contraction, by which the response to the cathode becomes progressively less, and that to the anode, greater, until eventually the anodal contraction equals or exceeds the cathodal.

Instead of CCc > ACc or AOc, the formula becomes ACc or AOc = or > CCc.

All degrees of the reaction of degeneration may be seen, from the complete form to a partial form, in which only the changed quality of the muscular response to the galvanic current exists. The degree of the reaction depends upon the activity or severity of the process of degenerative atrophy in the nerves and muscles. The complete form is seen only in traumatic lesions of the peripheral nerves of sufficient extent to produce solution of continuity, as in division by laceration or incision.

The only essential and pathognomonic sign of the reaction of degeneration is the peculiar sluggish quality of the response of the muscle to the galvanic current. The value of the reaction of degeneration as a diagnostic sign is in the differentiation of a peripheral from a central destructive lesion.

The Mild Degree of the Reaction of Degeneration.—When a paralyzing injury or disease of the peripheral motor neuron occurs, no electric

changes are at first seen. In a short time—from five to seven days—the responses of the nerve to the galvanic and faradic currents, and of the muscle to the faradic current, diminish, and by the end of the second or third week are completely lost, so that the strongest currents excite no contraction. The galvanic excitability of the muscle also declines for a few days, but during or by the end of the second week the response of the muscle to galvanic stimulation rapidly increases, and a very weak current induces a noticeable contraction, which is sluggish and wavy. At the same time the response to the cathode diminishes and that to the anode increases, until the anodal closure contraction equals or exceeds the cathodal closure, and the polar formula is reversed. These changes coincide with the process of degenerative atrophy in the nerve and muscle.

After a variable period of from four to eight weeks, a few days later than vestiges of returning voluntary motion, faradic and galvanic excitability of the nerve and faradic excitability of the muscle

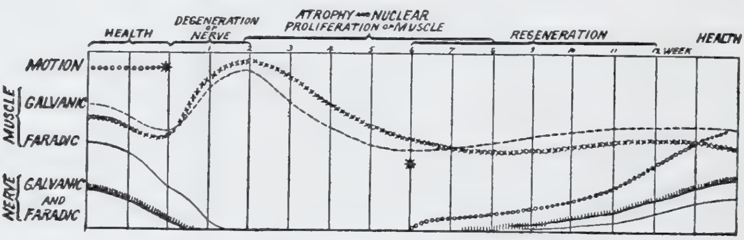

Fig. 202.—Graphic representation of the course of the mild degree of the reaction of degeneration (modified from Erb). The stars show, respectively, the sudden loss and beginning return of motion, which is shown by a line of circles. The galvanic excitability of the muscle is shown by lines of + + and — —, indicating the reversal of the poles; faradic excitability of the muscle, by a continuous line, and galvanic and faradic excitability of the nerve by a serrated line.

gradually return, the increased galvanic excitability of the muscle diminishes, the wavy, sluggish response becomes quicker and more lightning-like, and the poles assume their normal relations. This corresponds with the process of regeneration of the nerve and muscle.

The Medium Degree of the Reaction of Degeneration.—The medium degree of the reaction of degeneration is similar to the mild degree, except that the condition is more prolonged. Voluntary motion returns from the fourth to the eighth month, or even later, and regeneration begins, with restoration of the normal electric conditions, in from six months to one year.

The Severe Degree of the Reaction of Degeneration.—In the severe form regeneration does not occur, and the structures pass on to irreparable atrophy and proliferation of connective tissue. The faradic and galvanic excitability of the nerve and the faradic excitability of the muscle disappear and do not return. The galvanic excitability of the muscle, with the modal and polar changes, takes place as before,

reaching its height in the course of the second or third month, when it begins to decrease, and greater strength of current is required to elicit the contraction. The response continues to diminish until the

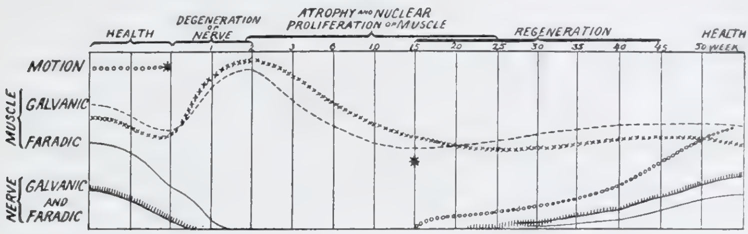

Fig. 203.—Graphic representation of the course of the medium degree of the reaction of degeneration (modified from Erb).

end of the second year, when the cathodal closure contraction disappears, then the anodal closure, until all electric excitability of nerve and muscle is permanently lost.

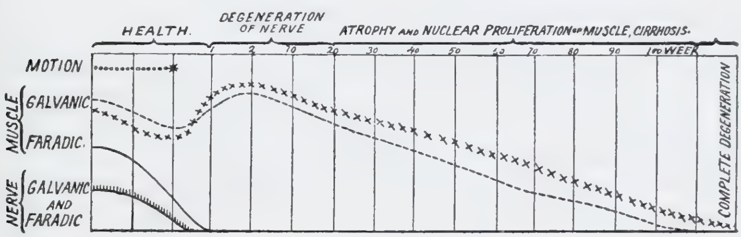

Fig. 204.—Graphic representation of the course of the severe degree of the reaction of degeneration (modified from Erb).

Atypical Forms of the Reaction of Degeneration.—(1) The quantitative change may be wanting, and the nerves continue to respond either

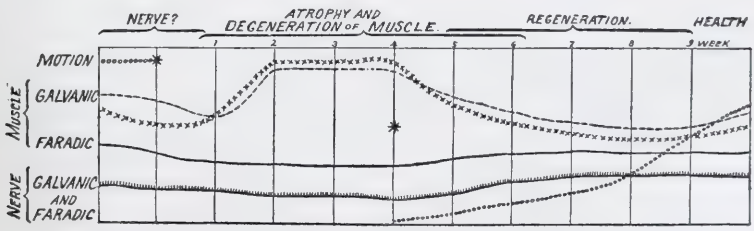

Fig. 205.—Graphic representation of the course of the partial reaction of degeneration (modified from Erb).

to the usual strength or, more commonly, to increased strength, of the faradic and galvanic currents, while the modal, qualitative, and

polar changes in the muscles are present. This is known as the *partial reaction of degeneration.*

(2) The partial reaction of degeneration may be further modified by persistence of the faradic excitability of the muscle, which responds to the ordinary strength of current, or may require an increased amount.

(3) The polar change may be absent, and the cathodal closure contraction continue more pronounced than the anodal contractions.

(4) Sahli notes another modification of the partial reaction of degeneration, in which all the responses are slow, those which are elicited by faradic excitation of the muscle and faradic and galvanic stimulation of the nerve, as well as those resulting from galvanic stimulation of the muscle.

(5) Occasionally the electric responses are characterized by a mixture of normal contractions with those suggesting the reaction of degeneration, both forms being displayed in the same muscle. This may be a feature of certain cases of partial reaction of degeneration, and is due to the activity of healthy muscle-fibers lying side by side with degenerated fibers in the same muscle. The term *mixed reaction of degeneration* has been applied to this phenomenon.

The Myotonic Reaction.—A peculiar quantitative-qualitative reaction has been described by Erb as characteristic of congenital myotonia (Thomsen's disease). The electric conditions in the nerves are not affected. The muscle responds to a current of diminished strength, and the contractions are slow and persist for several seconds after the withdrawal of the electricity. They are frequently rhythmic and wavy during the stabile application of the galvanic current. The electric excitability is thus analogous with the increased mechanical irritability in this disease.

The myasthenic reaction consists of rapid exhaustion of the faradic excitability of muscles. The muscle responds promptly and normally to the faradic current, but the contraction grows weaker, either with continuous application or with rapid consecutive applications, until the response ceases. After a brief period of rest excitability returns and the phenomenon is repeated. This reaction is probably pathognomonic of myasthenia gravis.

Myoclonic contractions are clonic movements of the fibers or bundles of muscles, in place of the normal tetanic response to the faradic current, following one another during the transmission of the current. Such contractions indicate weakness, and are not of important diagnostic significance.

The Neurotonic Reaction.—In the so-called neurotonic reaction the contraction persists after withdrawal of both the galvanic and faradic currents when applied to the nerves alone. Responses to the positive pole predominate over those to the negative pole, and anodal tetanus may be produced. The direct muscular responses are normal. The reaction has been found in a case of hysteria by Marina, and in

progressive muscular atrophy by Remak, but its significance is not understood, and it is at present to be regarded as a curiosity.

Electrocutaneous Sensibility.—For tests of the sensibility of the skin the faradic current is used. The patient should sit with his back toward the battery. A special testing electrode has been suggested by Erb, presenting a flat metal surface consisting of a great number of wires. The ordinary wire brush may be used. This electrode need not be moistened. The indifferent electrode is placed as in electro-muscular tests, and the differential electrode is placed lightly and evenly upon the skin, the secondary coil being removed from the primary, or the current otherwise reduced. The test begins with a weak current, which is gradually increased until the patient feels the first light prickly or tingling sensation. Care must be taken that the lightest perceptible sensation is differentiated by the patient from the painful sensations of a stronger current. Note is taken of the strength of current required.

Electric tests involve the same uncertain element as other tests for sensibility—the power of discrimination by the patient. The examination has consequently limited diagnostic value, and may be taken only as corroborative evidence of variations in tactile or pain sense. These tests are made most satisfactorily in unilateral disease, which permits control experiments upon the healthy side. In cases of anesthesia and analgesia, in which the ordinary tests fail to arouse a sensation, a very strong faradic current, administered by a wire-brush electrode, may cause severe pain.

Loss of faradic sensibility has been reported in locomotor ataxia dissociated from other forms of sensory defect. The electrocutaneous tests may be of service in detecting simulation. In such cases the minimal sensation is acknowledged by the patient with different strengths of current applied to the same areas in irregular succession. It is necessary that the patient sit with his back toward the battery, that he may not observe the manipulation. Cohn directs attention to the value of electrosensory examinations in bilateral disease as a means of determining accurately by measurements the variations in sensibility from time to time.

Increased electrocutaneous sensibility is found in tetany. Diseases of the vertebræ may be discovered by the use of electricity. An electrode, preferably the negative pole of the galvanic current, passed slowly along the spine, causes pain at points of disease, and by this method a single diseased vertebra may be differentiated.

These constitute the variations of electric excitability in disease. There are thus certain definite and easily observed effects of electricity, especially of electric currents. These occur in the nervous and muscular systems. The galvanic and faradic currents possess the property of exciting nerves in either their motor or sensory functions, and the galvanic current possesses the further property of acting specifically upon muscular tissue, as demonstrated by the phenomena of the reaction of degeneration. These facts may be made therapeutic-

ally available. For local use the choice of current and the method of application may be decided by the site of the lesion in the central or peripheral neuron. Faradic electricity is the choice in all diseases of the central neuron, and in those of the peripheral neuron unattended by the reaction of degeneration. For diseases presenting the reaction of degeneration the galvanic current is theoretically, and perhaps necessarily, preferable.

For exact use definite anatomic knowledge is necessary. Many peripheral nerves and muscles may be individually stimulated by the currents at points upon the surface, known as the "motor points," of which the following localization has been determined.

THE MOTOR POINTS

Fifth (or Trigeminus) Nerve.—*Action.*—Elevation and forward and lateral movements of the lower jaw.

Motor Points for the Muscles.—*Masseter.*—In the sigmoid notch of the lower jaw, just below the zygoma. (Moderately strong current required.)

Temporal.—In a perpendicular line through the zygoma, a finger-breadth within the border of the hair. (Moderately strong current required.)

Seventh (or Facial) Nerve.—*Action.*—Drawing of the face to the stimulated side and closing of the eyelid. The frontalis and corrugator supercilii often contract very weakly or not at all.

Motor Points.—(1) In the angle between the mastoid process and the ramus of the lower jaw. (The electrode is to be pushed upward and forward against the lower half of the ear and the border of the jaw.) (2) In the depression just above the tragus. (This point is not constant and is better for excitation of the middle and lower branches.)

Posterior Auricular Nerve.—*Action.*—Retraction of the ear and scalp.

Motor Point.—At the base of the mastoid process, level with or slightly above the middle of the ear.

Upper Branch of the Seventh (Supra-orbital) Nerve.—*Action.*—Wrinkling of the forehead and the eyebrow, and closing of the eyelids.

Motor Point.—At the outer end of the superciliary ridge.

Motor Points for the Muscles.—*Frontalis.*—At the outer and upper angle of the forehead, near the border of the hair. (Painful. The test should be made quickly.)

Corrugator supercilii.—Over the eyebrow, a little inside the point for the upper facial branch.

Orbicularis oculi.—Two points at the outer angle of the orbit.

Middle Branch of the Seventh (Infra-orbital) Nerve.—*Action.*—Expression of laughing, wrinkling of the nose and of the upper lip, or pouting of the lips.

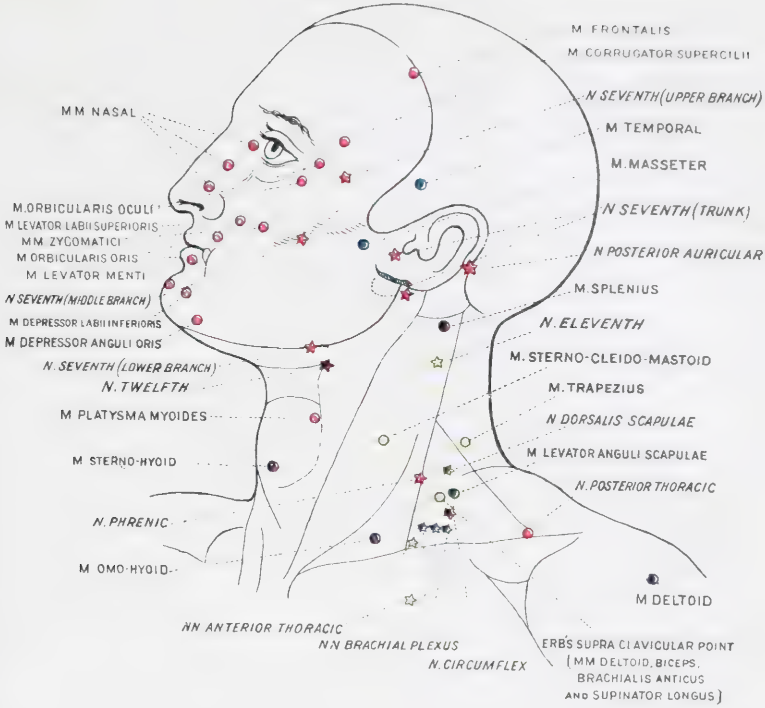

Fig. 206.—Motor points of the face and neck.

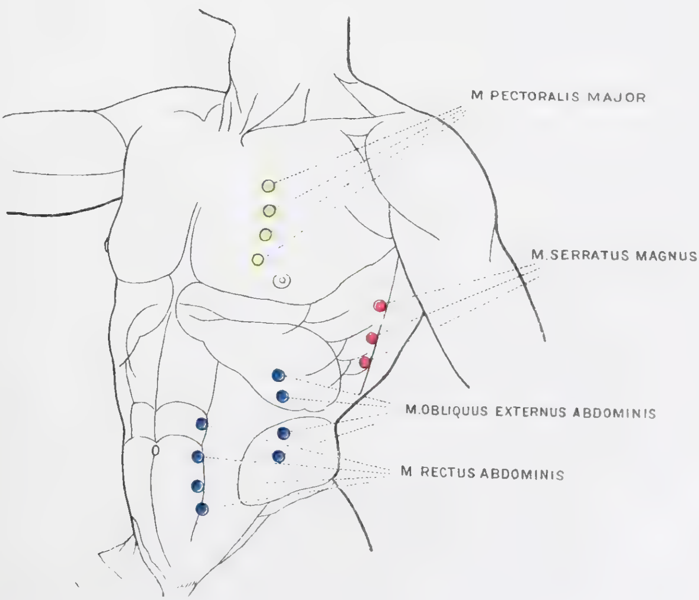

Fig. 207.—Motor points of the chest and abdomen.

MOTOR POINT.—At the junction with the zygoma of a perpendicular line dropped from the outer angle of the orbit.

MOTOR POINTS FOR THE MUSCLES.—*Nasal: Compressor, Pyramidalis, and Dilator.*—At the inner angle of the eye near the root of the nose.

Levator labii superioris alæque nasi.—On the cheek, just outside the nasal fold, level with the nares.

Zygomatici.—On the cheek, outside the point for the levator.

Orbicularis oris.—*Upper portion:* A finger-breadth above the lip, inside the outer angle of the mouth. *Lower portion:* Near the lip and somewhat nearer the middle line than the point for the upper portion.

Lower Branch of the Seventh (Infra-ductal) Nerve.—*Action.*—Elevation of the chin, pouting of the under lip, and retraction of the angle of the mouth downward and outward.

MOTOR POINT.—At the border of the lower jaw, just back of the groove for the facial artery.

MOTOR POINTS FOR THE MUSCLES.—*Levator menti.*—Near the middle line of the chin, just above the border of the lower jaw.

Depressor labii inferioris (*Quadratus menti*).—A little outside and above the point for the levator.

Depressor anguli oris (*Triangularis menti*).—Generally near the lower border of the jaw, a little outside the point for the depressor labii inferioris.

Platysma myoides.—In the anterior cervical triangle, level with the larynx.

Eleventh (Spinal Accessory) Nerve.—*Action.*—Extension of the head and elevation and rotation of the chin toward the opposite side.

MOTOR POINT.—About two finger-breadths below the upper angle of the posterior cervical triangle, near the trapezius.

MOTOR POINTS FOR THE MUSCLES.—*Sternocleidomastoid.*—At about the center of the muscle.

Trapezius.—At about the center of the anterior edge of the muscle.

Twelfth (or Hypoglossal) Nerve.—*Action.*—Movements of the tongue.

MOTOR POINT.—Close behind and above the hyoid bone.

MOTOR POINTS FOR THE MUSCLES.—*The Intrinsic Muscles of the Tongue.*—Direct stimulation.

Omohyoid.—Over the lower belly, between the insertions of the sternocleidomastoid.

Sternohyoid.—At the middle point of the belly of the muscle.

Cervical Nerves (External Branches of Posterior Division).—*Action.*—Drawing the head backward and downward.

MOTOR POINT FOR THE MUSCLE.—*Splenius capitis.*—Over the belly of the muscle, close under the mastoid process.

Phrenic Nerve.—*Action.*—Ballooning of the epigastrium and a noisy rush of air into the air-passages.

MOTOR POINT.—Behind the edge of the sternocleidomastoid,

between the upper and middle thirds, sometimes farther below. (The electrode is to be pushed beneath the muscle.)

Brachial Plexus.—*Action.*—Depending on the point, usually the distribution of the median and circumflex—flexion of the hand and fingers, elevation of the arm from the thorax, etc.

Motor Point.—Mainly in the whole lower and inner third of the supraclavicular fossa; parts also may be easily stimulated outward therefrom.

Dorsalis Scapulæ Nerve (Third, Fourth, and Fifth Cervical Nerves).—*Action.*—Elevation of shoulder-blade, with retraction toward spinal column.

Motor Point.—In the middle line of the posterior cervical triangle, three finger-breadths above the clavicle.

Motor Points for the Muscles.—*Rhomboids, major and minor.*—Direct stimulation, with intact trapezius, impossible.

Levator anguli scapulæ.—A finger-breadth below the point for the nerve and slightly behind it. (Not easily differentiated from the motor point for the nerve, inducing simultaneous contraction of the rhomboids.)

Long or Posterior Thoracic Nerve.—*Action.*—Movement of the shoulder-blade outward and forward; or visible contraction of the digitations of the serratus magnus.

Motor Point.—Close above the clavicle in front of the edge of the trapezius.

Motor Points for the Muscles.—*Serratus magnus.*—In the midaxillary line, particularly at the level of the sixth rib.

Suprascapular Nerve.—*Action.*—Rotation of the humerus.

Motor Points for the Muscles.—*Supraspinatus.*—Near the outermost angle of the supraspinous fossa, and attainable only when the trapezius is atrophied.

Infraspinatus.—At about the middle of the infraspinous fossa. Not easily stimulated.

Anterior Thoracic Nerves.—*Action.*—Adduction of the arm to the thorax.

Motor Points.—(1) Close above and behind the clavicle, near the outer border of the sternocleidomastoid. (2) Just below the clavicle, at the upper border of the pectoralis major. The electrode is to be pushed deeply, with the patient's arm hanging, and a moderately strong current is to be used.

Motor Points for the Muscles.—*Pectoralis major.*—Several, upon the anterior thoracic wall, over the chondrocostal articulations.

Lower Subscapular Nerve.—*Action.*—Rotation of the humerus.

Motor Points for the Muscles.—*Teres major.*—Occasionally, upon the muscle in the axilla.

Long Subscapular Nerve.—*Action.*—Adduction backward and downward of the arm.

Motor Point for the Muscle.—*Latissimus dorsi.*—At the anterior edge of the muscle, level with the angle of the scapula.

Erb's Supraclavicular Point.—*Action.*—Backward elevation of the arm from the thorax, and strong flexion at the elbow in position of pronation. (Muscles: Deltoid, biceps, brachialis anticus, and supinator longus.)

Motor Point.—Two finger-breadths above the clavicle and one finger-breadth behind the border of the sternocleidomastoid.

Circumflex Nerve.—*Action.*—Elevation of the arm backward from the thorax.

Motor Point.—In the middle line of the posterior cervical triangle, two finger-breadths above the clavicle.

Motor Points for the Muscles.—*Deltoid.*—Direct stimulation of anterior and posterior bundles.

Teres minor.—Occasionally upon the muscle in the axilla.

Musculocutaneous Nerve.—*Action.*—Flexion of the forearm.

Motor Point.—Two finger-breadths below the anterior axillary fold, at the inner border of the biceps.

Motor Points for the Muscles.—*Biceps.*—Over the belly of the muscle.

Coracobrachialis.—(1) At the inner border of the biceps, just below the center. (2) At the outer border of the biceps, three finger-breadths above the elbow. Push the electrode, which should be small, under the biceps muscle.

Brachialis anticus.—Behind the inner side of the biceps tendon, in the lower third of the arm. Not easily stimulated when the biceps is intact.

Median and Ulnar Nerves.—The ulnar and median nerves are easily stimulated simultaneously throughout the groove at the inner side of the biceps muscle (*Sulcus bicipitalis internus*).

The best position of the arm for the stimulation of these nerves and their muscles is one of very slight flexion, with greatest possible relaxation of the muscles. Only a weak current is needed.

In the hand the thenar and hypothenar muscles are most easily stimulated, and the lumbricales are often difficult to reach.

The reactions of the forearm and hand differ greatly in different people.

Median Nerve.—*Action.*—Pronation of the forearm, flexion and abduction of the hand, opposition and flexion of the thumb, flexion of the second and third phalanges of the fingers.

Motor Points.—(1) In the middle of the elbow-joint, usually directly outside of the biceps tendon. (2) In the middle of the wrist-joint, between the tendons of the flexor carpi radialis and palmaris longus, or at the ulnar border of the latter.

Motor Points for the Muscles.—*Pronator radii teres.*—Three finger-breadths below the elbow-joint, at the outer margin of the bundle of flexor muscles.

Palmaris longus.—A finger-breadth below the point for the pronator radii teres, and slightly nearer the middle line. Often difficult to differentiate from the flexor carpi radialis.

Flexor carpi radialis.—Directly below the point for the pronator radii teres, and a finger-breadth toward the radial side of the forearm.

Flexor sublimis digitorum.—Several, in the middle and lower thirds of the forearm, in a line from the internal condyle to the middle of the palm, and also toward the radial border of the forearm.

Flexor longus pollicis.—Four finger-breadths above the wrist on the radial border.

Thenar Muscles: Opponens pollicis; Flexor brevis pollicis; Abductor pollicis.—The points lie in a slightly curved line on the ball of the thumb.

Third and Fourth Lumbricales.—In common with the points for the interossei supplied by the ulnar nerve.

Ulnar Nerve.—*Action.*—Ulnar flexion of the hand and the first phalanges of the fingers; adduction of the thumb.

MOTOR POINTS.—(1) Between the inner condyle, and the olecranon, about one finger-breadth above the condyle. (2) On the ulnar side of the forearm, a little above the wrist.

MOTOR POINTS FOR THE MUSCLES.—*Flexor carpi ulnaris.*—On the border of the forearm, between the flexor and extensor surfaces, one hand-breadth below the internal condyle.

Flexor profundus digitorum.—In the middle of the forearm, level with the principal point for the flexor sublimis digitorum, toward the radial border. Not easily differentiated from the flexor sublimis digitorum.

Adductor pollicis.—On the dorsal surface, in the angle between the thumb and index-finger. Usually in combination with other small muscles of the thumb.

Hypothenar Muscles: Abductor minimi digiti; Flexor brevis digiti minimi; Opponens minimi digiti.—In a slightly curved line on the ball of the little finger.

Lumbricales and Interossei.—In the interosseous spaces on the back of the hand, somewhat nearer the wrist than the bases of the fingers.

Musculospiral Nerve.—*Action.*—Extension of forearm, hand, and fingers, with supination.

MOTOR POINT.—Slightly outside the point between the external condyle and the insertion of the deltoid. The electrode is to be pushed firmly and deeply between the biceps and triceps muscles, against the musculospiral groove. The application is sometimes painful and difficult.

MOTOR POINTS FOR THE MUSCLES.—*Triceps.*—Three points for the three heads usually in a horizontal line a hand-breadth above the olecranon. The long head may be also stimulated two finger-breadths below the posterior axillary fold.

Supinator longus.—Close above and in front of the external condyle.

Extensor carpi ulnaris.—Close to the posterior border of the ulna on its radial side, a hand-breadth below the olecranon.

Fig. 208.—Motor points, palmar surface, of the upper extremity.

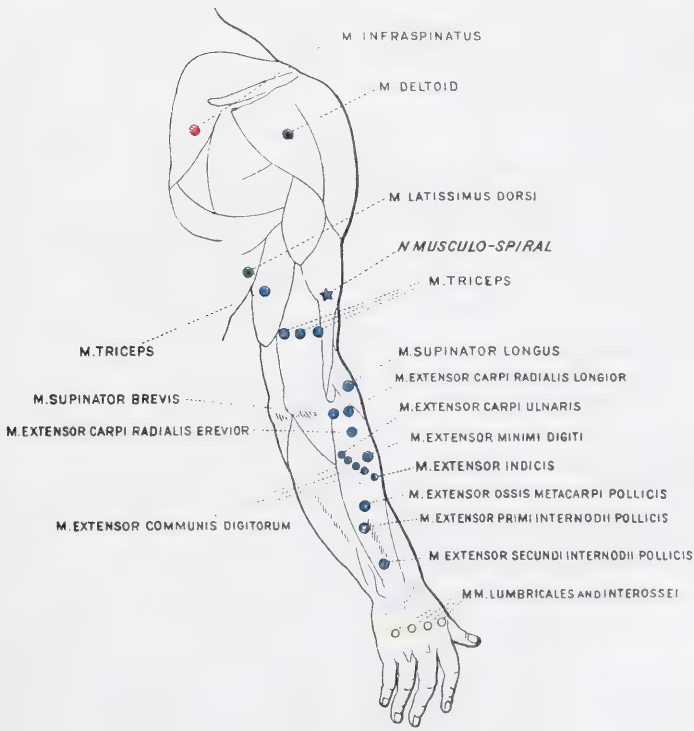

Fig. 209.—Motor points, dorsal surface, of the upper extremity.

Extensor indicis.—Slightly above the middle of the forearm, on a line from the external condyle to the base of the index-finger.

Extensor communis digitorum.—A series on an oblique line from the point for the extensor carpi ulnaris to the point for the extensor indicis, particularly at the middle point of this line.

Extensor minimi digiti.—One or two finger-breadths inside and slightly above the point for the extensor indicis.

Extensor carpi radialis longior.—Three finger-breadths below the external condyle, in the groove behind the supinator longus.

Extensor carpi radialis brevior.—Two or three finger-breadths below the point for the long radial extensor. Not easily differentiated from the extensor communis digitorum.

Supinator brevis.—Below and within the external condyle. A difficult muscle to stimulate, unless in atrophy of the overlying muscles. Cohn notes that in many persons there is a response to only one faradic pole, whereas the other, at the same point, elicits a response of some other muscle, as one of the extensors of the hand.

Extensor ossis metacarpi pollicis.—Between the points for the extensor indicis and the extensor primi internodii pollicis.

Extensor primi internodii pollicis (*Extensor pollicis brevis*).—In the center of the extensor surface of the forearm, three finger-breadths above the wrist.

Extensor secundi internodii pollicis (*Extensor pollicis longus*).—In the center of the extensor surface of the forearm, one finger-breadth above the wrist.

Upper Intercostal Nerves.—*Action.*—Movements of the ribs.

MOTOR POINTS.—On the upper borders of the intercostal spaces. Use a small electrode. Electric stimulation unimportant.

Lower Intercostal Nerves.—*Action.*—Retraction of the abdomen.

MOTOR POINTS FOR THE MUSCLES.—*Obliquus externus abdominis.*—Several, over the belly of the muscle, between the costal margin and the crest of the ilium.

Rectus abdominis.—Several, along the outer border of the muscle, most easily below the umbilicus.

Obturator Nerve.—*Action.*—Adduction of thigh.

MOTOR POINT.—At the outer end of the horizontal ramus of the pubis.

MOTOR POINTS FOR THE MUSCLES.—*Adductors* (*Longus, brevis, and magnus*).—Several, on the inner surface of the thigh, at the junction of the upper and middle thirds.

Anterior Crural Nerve.—*Action.*—Extension of the leg.

MOTOR POINTS.—(1) Above and behind the middle of Poupart's ligament. Deep pressure with the electrode. (2) In Scarpa's triangle, just outside of the femoral artery.

MOTOR POINTS FOR THE MUSCLES.—*Sartorius.*—Over the belly of the muscle, a hand-breadth below Poupart's ligament.

Quadriceps extensor femoris.—At the junction of the upper and middle thirds of the thigh, at the inner border of the rectus muscle.

Vastus internus.—A hand-breadth above the patella on the inner side of the muscular bundle. Easily stimulated.

Vastus externus.—On the outer side of the muscular bundle, about two hand-breadths above the patella.

Rectus femoris.—At the middle point of the anterior surface of the thigh, just below the point for the quadriceps extensor.

Superior Gluteal Nerve.—*Action.*—Extension of hip and abduction of thigh.

Motor Points for the Muscles.—*Gluteus medius.*—Between the trochanter major and the crest of the ilium. This test is much more satisfactorily made when the patient is made to stand on the limb that is not under examination, and support himself by his hands.

Tensor vaginæ femoris.—High upon the outer border of the thigh, just in front of the trochanter major.

Small Sciatic Nerve.—*Action.*—Extension, abduction, and rotation of thigh outward; elevation and adduction of buttock.

Motor Points for the Muscles.—*Gluteus maximus.*—Several points over the belly of the muscle.

Great Sciatic Nerve.—*Action.*—Flexion of the leg and plantar flexion of the foot.

Motor Point.—Midway between the trochanter major and the tuberosity of the ischium, in the gluteofemoral crease or just below it.

Motor Points for the Muscles.—*Semitendinosus and Semimembranosus.*—At the middle of the inner border of the thigh. At a common point just above the former, the long head of the biceps may be also simultaneously stimulated.

Biceps.—At the outer side of the thigh, below the level of the point for the semimembranosus and semitendinosus.

Internal Popliteal (Tibial) Nerve.—*Action.*—Flexion and wrinkling of the skin of the sole, and plantar flexion of the toes. The wrinkling of the skin of the sole is particularly characteristic.

Motor Points.—(1) Just above the middle of the popliteal space. (2) Between the internal malleolus and the tendon of Achilles.

Motor Points for the Muscles.—*Gastrocnemius.*—Over each head of the muscle, a hand-breadth below the knee.

Soleus.—Over the body of the muscle not covered by the gastrocnemius; the outer head also a hand-breadth higher than the inner. The preliminary test of the gastrocnemius reveals its outlines and facilitates the test of the soleus.

Flexor longus digitorum.—A hand-breadth above the internal malleolus.

Flexor longus hallucis.—Two or three finger-breadths above the external malleolus, close against the fibula. Deep pressure with the electrode.

Interossei.—Analogous with the points on the hand.

Abductor minimi digiti.—On the outer border of the foot, between the middle and posterior thirds.

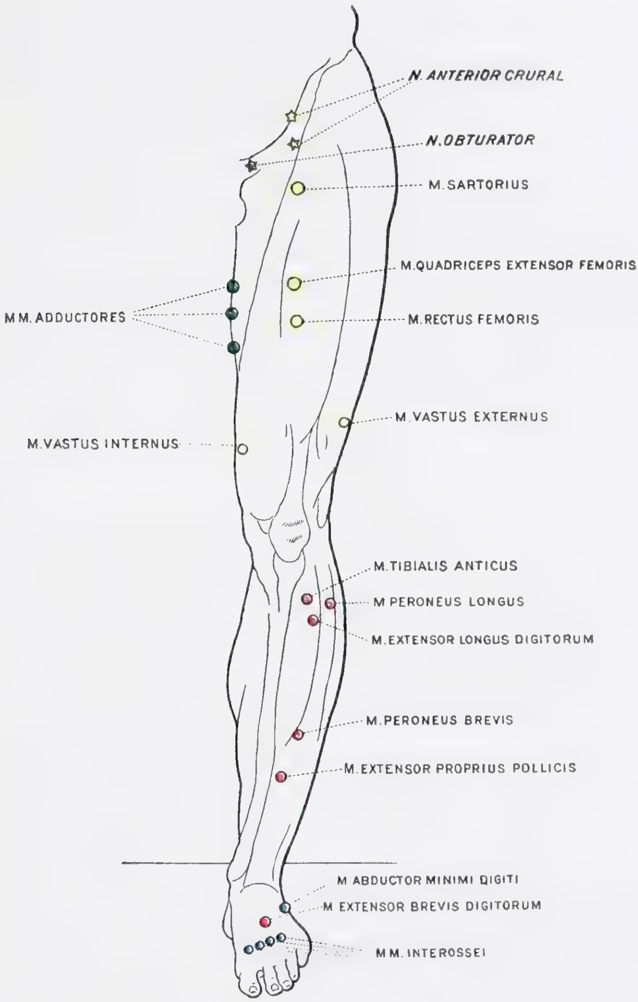

Fig. 210.—Motor points, anterior surface, of the lower extremity.

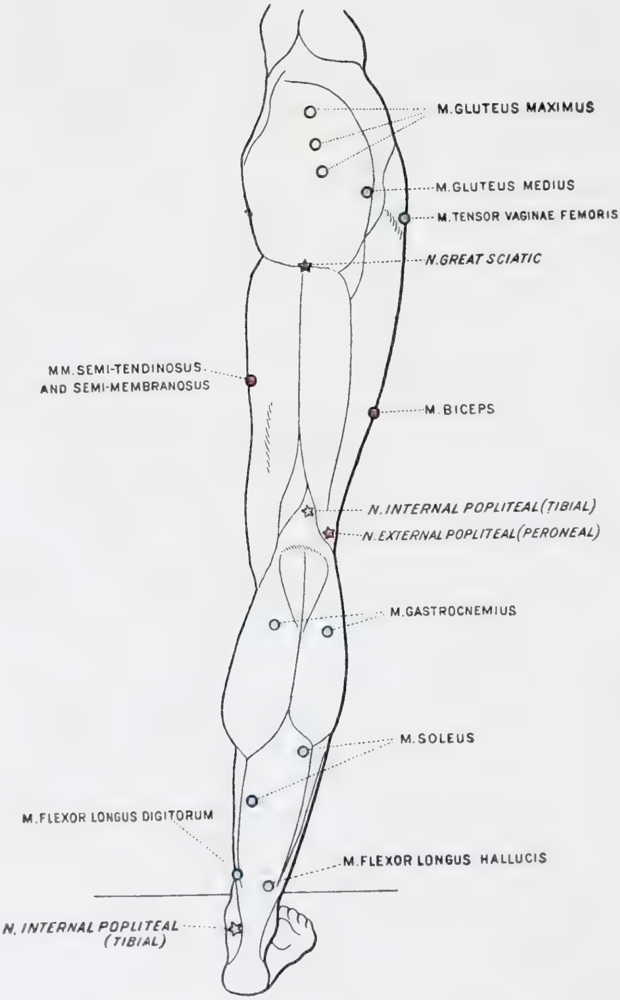

Fig. 211.—Motor points, posterior surface, of the lower extremity.

External Popliteal (Peroneal) Nerve.—*Action.*—Dorsal flexion of the foot and extension of the toes.

Motor Point.—At the outer angle of the popliteal space, close to the inner border of the tendon of the biceps. The best position for the examination of the leg nerves and muscles is attained when the patient is recumbent, with the knee slightly flexed. Pressure is to be applied directly.

Motor Points for the Muscles.—*Tibialis anticus.*—Two finger-breadths below the external tuberosity of the tibia, close to the crest. In children, at the junction of the upper and middle thirds of the leg.

Peroneus longus.—Two or three finger-breadths below the head of the fibula.

Peroneus brevis.—Halfway between the head of the fibula and the external malleolus. A moderately severe current required.

Extensor longus digitorum.—Three finger-breadths below the external tuberosity of the tibia. In children, at the junction of the upper and middle thirds, directly outside the point for the tibialis anticus.

Extensor proprius pollicis.—Close to the outer edge of the crest of the tibia, a variable distance (two to four finger-breadths) above the ankle.

Extensor brevis digitorum.—Between the external malleolus and the base of the toes.

GENERAL FARADIZATION

By general faradization, a term introduced by Beard and Rockwell, is designated a method of stimulating the entire organism by the faradic current. The effect of the application is mainly expended upon the muscles, the nervous and the circulatory systems, and the skin. The technic is as follows: The patient is stripped, covered only with a sheet or blanket, or with underwear permitting prompt exposure of limbs and trunk. He may be seated in a chair or recumbent in bed. One electrode, connected with the positive pole, is stationary, and may be fixed at the nuchal region, sternum, epigastrium, coccyx, or soles of the feet. This may be a large electrode of from three to four inches in diameter, but the smaller, common sponge electrode may be used, and its site changed if pain is caused. The originators preferred a large copper plate immersed in water, and applied to the soles of the feet, but this is not always convenient. The negative electrode, a sponge about two inches in diameter, is then stroked over the different parts of the body in regular order, beginning with the face and neck. On account of the sensitiveness of different parts of the head, particularly the brows, the current is introduced here very cautiously, and not infrequently by the *electric hand*, that is to say, by a moistened hand of the operator, who holds in the other the electrode, and then controls the current in its transmission through his body. The spinal column and muscles of the

back are then subjected to a stronger current, followed by the anterior thoracic and abdominal muscles, and, finally, the extremities. An average application of fifteen minutes is thus apportioned: to the head, one minute; to the neck, four minutes; to the back and abdomen, each, three minutes; and to the extremities, four minutes. The frequency of the applications is determined by the effect: in some cases daily séances are advisable; in others, they may be held every other day, or twice a week.

The immediate result of the treatment may be described as refreshing and exhilarating. The originators lay especial stress upon the sense of comfort following stimulation of the visceral nerve-trunks of the neck. The active contractions of so many muscles act as direct stimulation of the circulation, with corresponding benefit. This sense of comfort lasts several hours. Later, usually on the following day, reaction is noted in increased pain in the muscles, nervousness, and weakness, with intensification of special symptoms, as headache or insomnia. If the reactionary discomfort continues or grows more marked after successive applications, the treatment is too severe, and must be moderated or abandoned altogether. Ordinarily, toleration is established, stronger currents and longer and more frequent applications are made, and the ensuing exhaustion is less.

The indications for general faradization are states of debility in which muscular exercise is needed and cannot be otherwise obtained. It is consequently beneficial in the exhaustion of the nervous and muscular systems of neurasthenia and hysteria, and its use in these conditions is attended by satisfactory results. It may be summarized as indicated in any form of nervous disorder without organic lesion, characterized by inertia.

INDICATIONS FOR THE THERAPEUTIC USE OF ELECTRICITY

Diseases of the Central Neuron

Diseases of the Brain.—The organic lesions of the brain most often calling for palliative treatment are hemorrhage, thrombosis, and embolism. In these conditions, when not immediately fatal, there is greater or less residual paralysis, resulting in contractures. The tendency of a partially crippled member is toward complete disability, and the preservation of even part of its function is to be energetically sought. Professor Erb has demonstrated that not all apparently affected structures have been destroyed, but some, by contiguity or by association of function, are rendered inactive, so that the picture is given of more complete paralysis than actually exists. The restoration of the secondarily involved muscles may render the limb useful. The stimulation of individual muscles thus becomes a conservative measure of greatest value, and for this stimulation there is no such effective agent as electricity. The weakened muscles should be excited by the faradic current, at first, once daily, and later, every other day or twice a week. One sponge electrode of moderate size

should be placed at an indifferent point, as the sternum or nuchal region, and the other should be stroked over each limb for from five to ten minutes, being allowed to rest momentarily upon the motor points to produce vigorous but not painful contractions. The muscles to which special attention should be given in ordinary cases are, in the upper extremity, the supraspinatus, infraspinatus, deltoid, triceps, supinators, pronators, and extensors of the wrist and fingers; in the lower extremity, the quadriceps and the extensors of the foot and toes. Of the muscles supplied by cranial nerves, the trapezius is most prominently involved, and next in importance are the muscles of the lower two branches of the facial. Electric stimulation of the tongue is possible through the motor point of the twelfth nerve, but hardly necessary.

The electric treatment of hemiplegia should not be undertaken until the stage of activity of the pathologic process in the brain has passed. This varies from two to four or five weeks. In properly managed cases the permanent conditions are established in from three to six months, and further manipulations are valueless.

In neglected cases in which an energetic attempt has not been made to counteract the tendency to deformity, muscular tone may be partially restored in the antagonists of contracted muscles, and the rigidity reduced, even after the lapse of months.

Diseases of the Peripheral Neuron

Acute Anterior Poliomyelitis.—For intelligent management of a case of infantile paralysis general knowledge of the pathologic process is necessary. The lesion is an acute inflammation of the multipolar cells of the anterior horns of the spinal cord, and may be circumscribed or general, in either event of varying intensity. Thus some cells are destroyed, others only damaged, and of others there may be simply a temporary arrest of function. Many cells escape. The result is disability of muscles controlled by the affected cells. This disability appears at first to be complete. Their representation in the anterior horns is multiple, and it is now well known that an individual muscle may receive its trophic control from all groups so widely separated as to lie even in different horizontal segments of the cord. In the average case atrophic and healthy fibers lie side by side, and the disposition of this partially diseased muscle is toward complete disuse. The distribution of the paralysis is thus much more wide-spread at the onset of the attack than is warranted by the extent of the lesion. The restoration of tissues destroyed by the infection cannot be expected, but for the damaged structures, and for those suffering from vicious companionship, active intelligent treatment may do much. The claim may be fairly made that the return of function in capable parts may be so effective as to constitute a cure. In fact, when infantile paralysis is properly treated, its terrors fade away, and the deformities which have been so common may be not infrequently attributed to neglect.

For this happy consummation there is no such effective agent as electricity. In the muscles in which healthy and diseased fibers lie side by side electrodiagnostic tests reveal many forms of response, but usually these are definite loss of faradic excitability and the presence of complete or modified reaction of degeneration; that is to say, the muscular contractions in response to galvanic stimulation are sluggish or wavy, and with greater activity when the positive electrode is used at the motor point. The use of galvanic electricity in treatment is consequently imperative.

Electric treatment is not begun until the acute inflammatory stage has subsided. During this period the limbs are kept at rest. In from two to four weeks after the onset active measures are begun. As the patients are usually children, great care is taken that they are not hurt or terrified. They are educated to the appearance of the apparatus, are allowed to handle the electrodes, and the first applications are made without the current. When the confidence of the patient is assured, a gentle current of electricity is allowed to flow through the electrodes, and this is gradually increased until a visible contraction of the muscle occurs. The technic of the operation is as follows: The limb to be treated is placed in a relaxed and comfortable position in a good light. The sponge electrodes, of from one and one-half to two inches in diameter, are moistened in warm water, and one is placed at an indifferent point, as the sternum, the nuchal region, or the epigastrium. This is usually the cathodal electrode, but if the muscular contractions are more energetic to the negative than to the positive pole, the latter is to be applied at the indifferent point. The remaining electrode is then stroked gently over the affected muscles with light, steady pressure, and is lifted from the skin at the end of each stroke. It may be allowed to rest casually upon the motor points.

The applications should be made every day, and are guarded in intensity by the toleration of the involved muscles. These are to be gently stimulated for from ten to fifteen minutes. If increased disability follows, even though temporary, a weaker current should be used, and the applications less frequently made.

Occasionally the muscles respond to the faradic current, or to both currents combined, presenting so-called *mixed* reactions. In these cases the use of the faradic current, or of both currents synchronously ("galvanofaradization"), is indicated. In fact, when improvement is well established, the faradic current may be substituted for the galvanic, under the same general rules of administration. The object sought is the restoration of muscular contractility. This is a visible effect of the treatment, and determines the choice of current.

The treatment should be persisted in for a long time. Improvement is noted even after six months or a year. The proof of the value of electricity in this disease is seen in neglected cases. Children who have lost the use of the limbs for years and present flaccid and wasted muscles regain their function after the use of electricity when all

other measures have failed. A child now under observation who had been unable to take a step for six years walked after four months' use of the galvanic current. Although accurate anatomic knowledge and skill are necessary to the proper administration, the nurse or parents may be instructed in the individual case and routine treatment thus secured.

Neuritis.—There are two forms of neuritis: inflammation of the neuroglia, *interstitial* or *connective-tissue neuritis* or *perineuritis;* and inflammation of the nerve-fiber, *parenchymatous neuritis.* Clinically, the former is limited to individual nerves or nerve groups, as in brachial neuritis or sciatica; and the latter has a marked tendency to bilateral symmetry—multiple neuritis. Interstitial affections show only slight disposition to atrophy, and are frequently regarded as neuralgia, whereas multiple neuritis is attended by acute and extensive atrophy and the reaction of degeneration. The lesion is differentiated from one of the anterior horns by the presence of sensory symptoms, which introduce an additional element for consideration in relation to therapy. Electric treatment is indicated by the symptoms, and is not in any way dependent upon the cause of the disease.

Interstitial Neuritis.—This is not infrequent, and is sometimes differentiated with difficulty from neuralgia, which may be, indeed, its obtrusive symptom. The painful and paralytic affections of the brachial plexus and sciatic nerve may be *idiopathic* or *rheumatic,* or result from strain or other form of injury. The musculospiral nerve is more often injured than any other nerve, and Erb's paralysis, of the deltoid, biceps, brachialis anticus, and supinator longus, is also a traumatic lesion. Electrodiagnostic tests reveal diminution of electric excitability in response to either current, with rarely, if ever, the reaction of degeneration. Electric treatment is indicated by the symptoms, and is not in any way dependent upon the causes of the affections. During the acute stage it should not be attempted. After two weeks the muscles may be stimulated gently for ten or fifteen minutes each day by the faradic current, of sufficient strength to induce contractions. The electrodes may be permitted to rest upon the tender points, not to cause pain, but by gentle, stabile applications, with current increased in strength from day to day, until toleration is established.

Facial paralysis is to be classified here. The tumefaction of the seventh nerve, when inflamed, subjects it to pressure in its course through the Fallopian canal. Facial paralysis may be consequently more severe than other peripheral palsies, and more frequently shows the reaction of degeneration. The electric treatment is regulated by this, and galvanization or galvanofaradization is the method of application.

The electric treatment of sciatica is similar to that of brachial neuritis. The faradic current is preferable. The electrodes should be held momentarily upon the painful points, particularly at the sciatic notch and in the popliteal space; more rarely behind the mal-

leoli and along the crest of the ilium. The treatment should include stimulation of the muscles of the leg.

Parenchymatous or Multiple Neuritis.—The conditions differ from those of interstitial neuritis. The disease is due to a poison, and the symptoms are usually bilaterally symmetric. Extensor muscles of the limbs are most commonly affected, but there are numerous exceptions to this. Neuritis due to the influenza toxin is bizarre and frequently atypical. The results of influenza may be said to have been seen in every form of nervous disease. While alcoholic neuritis usually affects the musculospiral distribution of the upper extremities and the crural, tibial, and peroneal distributions of the lower, there are occasional irregular forms, as in one case of palsy of both bicipites brachiorum.

The electric treatment is that of degenerative atrophy of the muscles due to destruction or damage of the peripheral motor neuron. The same rule applies as in the treatment of atrophic spinal paralysis. The applications should not be begun until the subsidence of the acute stage. The galvanic current should be first used, followed later by the faradic or by the combined galvanofaradization. It is to be noted that the distribution of the paralysis is that of the peripheral nerve-supply, and not irregular, as in lesions of the anterior horn cells.

Functional Nervous Disorders.—Under the term functional disorders are included conditions of the nervous system in which there is no known anatomic lesion, or, to speak more exactly, no change in the structures capable of detection by methods of examination now known. These disorders are neurasthenia, hysteria, and numerous vague local symptoms classified under one or the other of these heads. Although physical disability is implied, a pronounced mental defect is essential and largely influences treatment. Electricity has long been regarded as an important remedy, and by some practitioners as specific. As muscular contraction, increased tissue metabolism, and sensory stimulation enter into account, the benefit of electricity can hardly be questioned; but the result must be largely attributed to suggestion.

The form of electricity and the method of application are determined by the operator. Without enthusiasm and encouragement any treatment may fail, and with these almost any therapeutic measure may succeed. The faradic current is the most convenient and is impressive. With the static machine the need of removing clothing is obviated, and the mental impression is, perhaps, deeper. Jacoby,[1] who discusses the whole subject in a non-partizan way, says he "should consider it a hardship to be obliged to treat many neurasthenics were he to be debarred from the use of a static machine."

Neurasthenia and hysteria appear as either constitutional or acquired diseases. In a case of constitutional basis mental defect or instability is assumed, and a condition of mind is presented in which a suggestive plan of treatment, such as is offered by electricity, will

[1] Cohen's System of Physiologic Therapeutics.

be entertained. In acquired states the nervous debility is a true exhaustion of vitality, which responds only to rest and recuperative measures. Among these Weir Mitchell placed electricity, but of the five principles governing his scheme of treatment, he felt that he could best dispense with this.

CONCLUSIONS

The following conclusions may be stated as representing the status of electricity in general medical practice today:

(1) The therapeutic effects are direct and indirect, the former being due to suggestion and the latter to general improvement in nutrition. As an aid to suggestion, any form of electricity is available; static electricity is at present most favorably regarded.

(2) The physical effects of electricity are general and local. The general effects follow muscular and sensory stimulation and increased activity of metabolism. The most available method of application is general faradization or the static current.

(3) For local use either the faradic or galvanic current may be used. In destructive diseases of the central neuron the faradic current is indicated; in destructive diseases of the peripheral neuron, presenting the reaction of degeneration, the galvanic current.

RADIOTHERAPY

By Henry K. Pancoast, M.D.

The therapeutic properties of x-rays are dependent primarily upon certain reactions or changes directly induced in exposed tissues, as a result of the absorption of x-ray energy by matter entering into the composition of the cells. X-rays are now believed to produce certain effects in most, if not all, molecules or atoms of matter through which they pass, and the complex molecules of cell protoplasm are no exception, and, secondarily, as a result of these effects upon cell protoplasm, certain reactions become manifest in the tissues exposed. In the employment of this form of energy for therapeutic purposes the desired result in any instance may be brought about either through the direct effect of radiation, as in the destruction of malignant growths or in the removal of hair; or it may be derived indirectly through the reaction induced, as, for example, in the treatment of tuberculous adenitis, wherein the stimulation engendered by the tissue reaction is the important factor in the healing process.

The most typical manifestation of tissue reaction to Röntgen radiation is an x-ray dermatitis. In one of the first instances of this accidental result of overexposure of a patient the dermatitis was accompanied by a loss of the hair in the part affected, which suggested to Freund the possibility of some practical use being made of this undesirable effect upon normal hair in healthy skin, and in 1896, or within a year after the discovery of x-rays, he made the first therapeutic use of them in an unsuccessful attempt to depilate a large pigmented nevus. In the following year, however, the first *cures* by x-ray treatment were reported by Freund and Kümmel, each of whom had successfully treated a case of lupus vulgaris.

Regarded solely from the standpoint of a therapeutic agent, radiation differs in three essential respects from all other remedial agents. In the first place, the physiologic action of Röntgen rays is purely local in the tissues exposed, as is also any therapeutic action induced, with one or two exceptions, in which more general effects may be produced indirectly. Secondly, the cumulative effect of repeated administrations is more prolonged; and, thirdly, no other therapeutic agent possesses efficiency in treatment in such a wide variety of pathologic conditions. There are two very evident reasons that go far to explain this last point of difference. One is the fact that quite different therapeutic effects may be derived from the varying degrees of tissue reaction that may be induced through the

proper regulation of x-ray dosage. The second reason is a selective action exerted by the rays upon certain cells, by virtue of either the specialization of the latter, their vitality, or their comparative development from the embryonic standpoint. This selective action is likewise more or less controllable through dosage regulation.

The discovery of each new use for x-ray treatment has naturally been the result of experimental tests, hence it has had to pass through a stage that has been almost purely experimental, and which has been largely characterized by an almost indiscriminate use of radiation. While this stage can hardly be regarded as terminated, it is evidently now gradually merging into a period of conservatism in which the application of x-ray therapy is slowly but surely being limited to the treatment of those conditions only in which its efficiency has merited general recognition.

An intelligent comprehension of the principles of x-ray therapy, and also of the therapeutic use of radium, requires a clear understanding of certain essential facts concerning the modern theories in regard to the ultimate or subatomic structure of matter, the production of x-rays, the identity of the latter, and such of their properties as are concerned in the production of changes in the molecular structure of matter. Largely through the study of the phenomena taking place in the excited x-ray tube, physicists have experimentally determined, first, that the ultimate *material* constituent of all elements, and, therefore, of all forms of matter, is one and the same thing, namely, the *negative corpuscle*, which is also directly concerned in x-ray generation, and is, perhaps, analogous with the *beta* rays given off by radium; secondly, that the *identity* of each of the elements depends upon the number and arrangement of these corpuscles entering into its atomic or molecular structure; and, thirdly, that the atomic weight of an element is proportionate to the number of corpuscles its atom contains. All negative corpuscles are believed to be in a state of constant motion within the confines of the atomic structure, and each one is regarded as possessing the same negative electric charge, hence each exerts a constant, mutually repellent action upon the other. The *stability* of the chemical atom, or of the molecular structure of which it forms a part, whether the latter be an element or a compound, is believed to depend upon the maintenance of equilibrium between the two opposing forces of the combined negative charge of all the corpuscles in the atom, and the positive electric charge of the atom itself.

The negative corpuscle is directly concerned in the production of x-rays. The high potential charge at the negative pole or cathode, C (Fig. 212), of the excited x-ray tube disturbs the electric equilibrium of the atomic structures of the molecules of gas in the immediate vicinity to such an extent as to cause one or more negative corpuscles to be expelled from each molecule at the enormous velocity of 20,000 miles or more per second. By constructing the cathode in the form of a concave disc, the so-called "cathode stream," S, of these moving negative cor-

puscles is brought to a focus, and at their focal point is placed the metal target, A, usually a portion of the anode, for the purpose of receiving the impact of the particles at their point of greatest concentration. At the moment of impact the energy of each moving corpuscle (represented by its mass times its velocity squared) is transformed into that of heat. Regarding a moving negative corpuscle as an electrically charged body, it is believed that each one is accompanied in its flight by lines of electric force which radiate from it in all directions through the ether, and that at the high velocity at which it travels through the ether medium the latter imposes a certain drag upon these accompanying lines of force, causing them to be distorted or bent backward more or less, depending upon the velocity of the corpuscle. When a corpuscle strikes the target and loses its own energy of motion, there is an immediate readjustment or straightening of the distorted lines of force, which originates a disturbance or pulse in the surrounding ether. This single ether impulse travels radially in all directions from the point of impact like a constantly enlarging

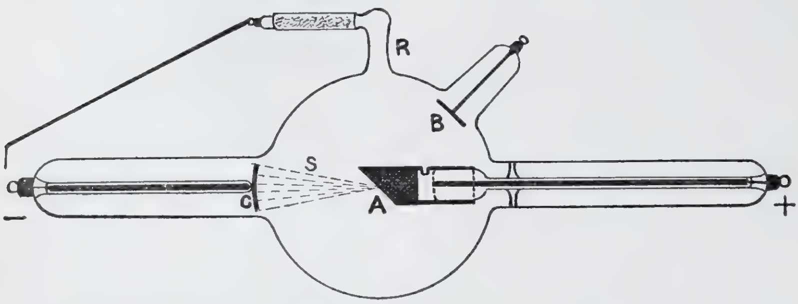

Fig. 212.—Diagram of modern type of *x*-ray tube.

hollow sphere, and at a velocity proportionate to that of light. Such an impulse, so produced, and traversing the ether medium in such a manner, is the present theoretic conception of the identity of an *x*-ray impulse.

Whether this conception of *x*-ray identity and production be correct or not, upon such a basis, at least, all facts pertaining to the measurement and the means of controlling *x*-ray output are most readily explained and most easily understood. As the impact of a single corpuscle originates but a single *x*-ray impulse, it follows that the number of *x*-ray impulses produced or the *intensity of* x-*ray output* at any *one time*, or the *volume of radiation* for a *given time*, will be in direct proportion to the number of corpuscles striking the target, which in turn will depend upon, first, the number of molecules of gas to be ionized or the *amount of gas* in the tube; and, secondly, the *volume of the exciting current* delivered to the tube to ionize the gas at hand. Proper control of both of these factors is absolutely necessary in order to regulate the volumetric output of an *x*-ray tube.

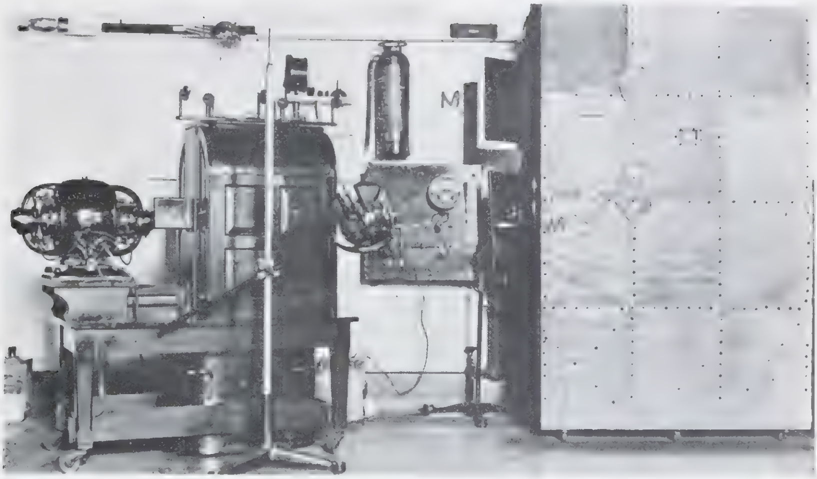

Fig. 213.—Interior of a portion of an x-ray operating room, illustrating an example of one of the two *safe* methods of protection for the operator. To the right of the transformer is a lead booth, containing a switch-table (Fig. 216, T), upon which are mounted all switches for operating the apparatus, thus rendering the operation of the latter impossible except from within the booth. The apparatus is always in direct view through the narrow entrance, and the tube, patient, and all parts of the room can always be under observation through suitably placed and adjustable mirrors, M-M, while the operator may be comfortably seated on a bench (Fig. 216, B).

This booth weighs about 700 pounds, but being mounted upon heavy castors, it can readily be moved about. The inside dimensions are 3 by 4 ft. by $6\frac{1}{2}$ ft. high. The front, which always faces the excited tube, is covered with $\frac{3}{16}$ in. lead. This alone, like the ordinary lead screen, cannot be considered a sufficiently safe means of protection for anyone doing x-ray work constantly, as such an individual should be additionally protected *on all sides and from above from secondary radiation.* For this purpose, the top, right end, and greater portion of the back of the booth here illustrated are covered with $\frac{1}{16}$ in. lead, while most of the entrance, at the end next the apparatus, can be closed up by a lead door. A large window in the back opens directly into one of the windows of the room, thus affording ample light and ventilation.

The only other safe method of protection consists in operating the apparatus in a similar manner from an adjoining room, with a lead partition between the two rooms. The apparatus may be placed in the same room if desirable, in which case the secondary discharge is carried to the tube in the x-ray room on well insulated long conducting wires. The only exact test for absolute protection from exposure from any source is for the operator to be able to keep an unexposed light protected plate or film near where he is stationed for several days, without it showing any signs of fogging on being developed.

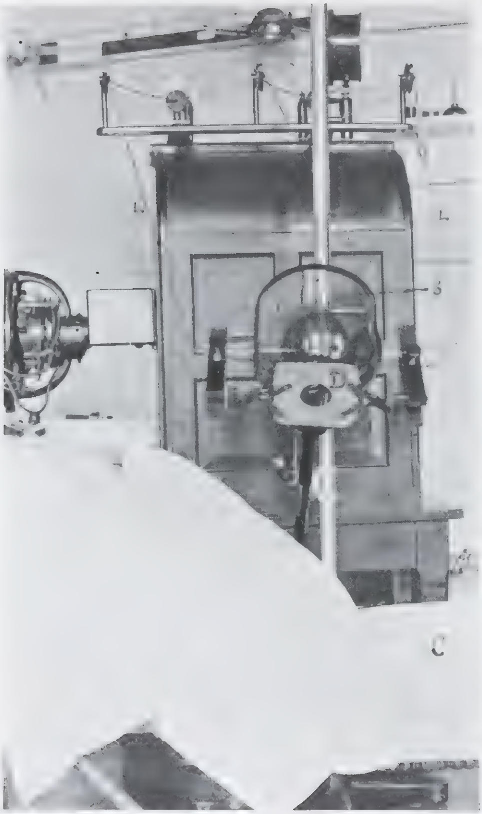

Fig. 214.—Showing one of the *essential* means of protection of the patient during a therapeutic exposure. It is always advisable to have the patient lying down on a couch, *C*, or table, when any parts, except possibly the extremities, are being treated. The thick lead glass tube shield, *S*, serves to cut off most of the rays laterally, though such a device is by no means an absolute protection against exposure, and does not preclude the possibility of the hair of the scalp coming out. It further serves to protect from any dangers arising from the possible collapse of the tube. An adjustable lead diaphragm, *D*, at least $\frac{1}{8}$ in. in thickness, should always be used when the area treated is small, and the aperture should be no larger than is necessary for the exposure of the area under treatment. The surrounding healthy parts may be further protected by lead foil, especially during the treatment of any portion of the face or head. When the skin is intact, the exposed area should be covered by some form of *x*-ray filter, such as thin aluminum, thick leather gauze, or the clothing, unless the most superficial radiation, as of the skin itself, is desired.

Each of the lead wires, *L-L-L*, from the apparatus to the tube should be unwound from a spring reel (Fig. 215), which will quickly wind up its wire and prevent it from dropping on the patient should it become detached from the tube.

Fig. 215.—*X*-ray conductor reels.

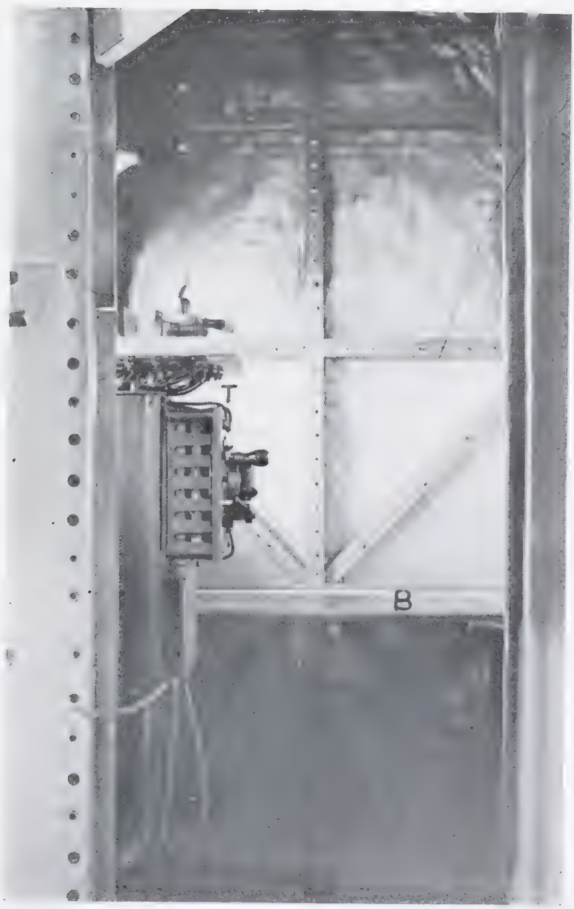

Fig. 216.—Showing interior of lead booth.

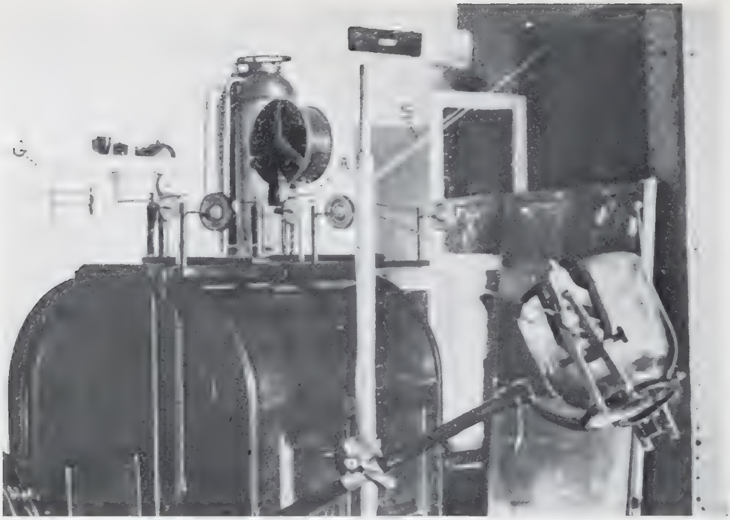

Fig. 217.—Showing a simple method of measuring spark-gap resistance of the tube, and of lowering its vacuum, from within the lead booth, and while the apparatus is in operation. This can be accomplished by means of the cords, *S*, one of which operates the adjustable parallel spark-gap point, *G*, and the other, the regulating spark point, *R*.

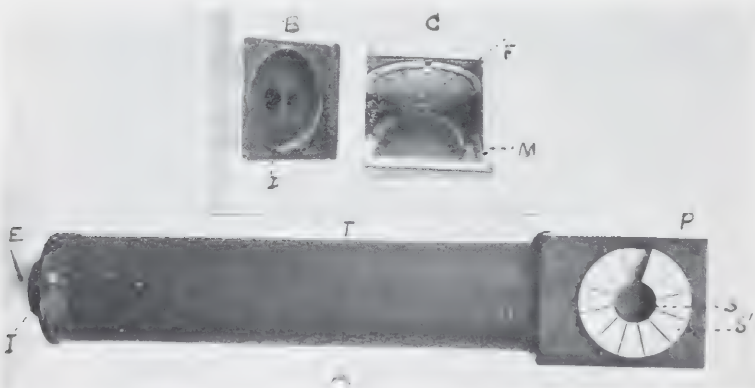

Fig. 218.—A modified form of the Benoist penetrometer, the most reliable of all the instruments devised for the *direct* determination of the approximate degree of penetration of the major portion of the x-ray output. While by no means exact, and not adapted for routine use nor suitable for general dosage estimation, this instrument possesses a distinct value in testing the output of tubes in order to determine its quality in a general way, especially when the quality of the output is uncertain. *A*, shows the instrument intact, consisting of a telescopic tube, *T*, with an aperture for the observer's eye at one end, *E*, and a diaphragm, *D*, at the other end, *B*, which can be seen on removing the wedge-shaped box, *P*, the interior of which is shown in *C*. Into the front of this box, *P*, which is to be held directly facing the target of the excited x-ray tube, is inserted a standard silver disk, *S*, surrounded by twelve aluminum sectors, *S'*, which increase regularly in thickness from the first to the twelfth, so that the latter is twelve times the thickness of the first. Behind the silver disk and sectors is placed a fluoroscopic screen, *F*, which is illuminated by the rays from the excited tube which pass through these metals. On the inner surface of the screen are mounted lead numerals corresponding to the numbers of the respective aluminum sectors. On looking through the instrument, the observer sees the *reflection* of the illuminated screen in the mirror, *M*, placed at 45°, but the two apertures in the diaphragm, *D*, permit only the reflected portion corresponding to the silver disk, *S*, and *one* of the aluminum sectors, *S'*, to be seen at one time. When using the instrument, the operator revolves the diaphragm, *D*, by means of the indicator, *I*, until the degree of reflected illumination back of one of the aluminum sectors matches that back of the central standard silver disk. The number of this sector is indicated either by its lead numeral on the screen, *F*, or on the circular scale around which the indicator, *I*, revolves. This number indicates in terms of the Benoist scale the approximate degree of penetration of the major portion of the rays generated at the time, but the proportion of the output which is thus represented is a very indefinite and variable quantity, however.

Penetration, as applied to an x-ray impulse, implies the amount of energy it possesses to enable it to pass through matter. The amount of energy represented in an impulse depends upon the amount of readjustment in the lines of force and the rapidity with which this occurs. The higher the velocity of the corpuscle, the greater is the distortion of its lines of force, and the greater, therefore, is the amount of readjustment that must ensue. Likewise, the greater the speed of the corpuscle, the shorter is the time of the impact and the quicker the readjustment. Therefore, the energy or the degree of penetration of an x-ray impulse depends primarily upon the *velocity of the corpuscle*. The velocity of the latter at the time of its *impact* depends, first, upon the initial velocity imparted to it by the potential of the negative charge at the cathode; and, secondly, upon the amount of resistance offered by molecules of gas in its path. It is, therefore, possible to control penetration to a certain extent through the adjustment of the *amount of gas* in the tube and of the *voltage* of the exciting current, the former being by far the more important means of control, however.

It will be noted that current volume, current potential, and the amount of gas in the tube are the essential factors in controlling the volume and penetration of x-ray output, but in order to *properly* control the latter, the adjustment of these factors becomes a very intricate problem, as any variation in any one of them usually necessitates an appropriate readjustment of the other two. For example, to increase x-ray volume, the current volume must be increased, but in addition the vacuum must be lowered by means of the automatic regulator, R, Fig. 212, to supply more gas. Increasing the amount of gas in the tube tends to lessen penetration, however, and it is only by a proper relative adjustment of current volume and amount of gas in the tube that the effect of the increase in the latter in lessening penetration can be obviated. It is upon an adequate understanding of these means of controlling the quality and quantity of x-ray output and the ability to apply them correctly that the success of the x-ray operator largely depends.

The *density* offered by any substance to the penetration of x-rays through it implies the amount of energy each molecule of that substance is capable of taking from an x-ray impulse passing through its structure. The impulse loses its energy in causing an acceleration of the motion of the negative corpuscles, and the greater the number of the latter in a molecule, the greater the amount of energy lost in each molecule of the substance traversed. Therefore, the number of molecules of a substance through which an x-ray impulse of any given penetration will pass will depend upon the number of corpuscles in each molecule, and as atomic weight is believed to depend upon the number of corpuscles in the chemical atom, penetration is, to a certain extent, proportionate to atomic weight, as is also the density of a substance to x-rays.

Penetration is equally as important a factor in Röntgen therapy

as it is in radiography. In treating lesions beneath the skin surface the energy of the impulses should be sufficient to permit them to pass through the overlying structures and to reach those tissues toward which the treatment is to be directed. On the other hand, whether the lesion be deep or superficial, the average penetration should not be more than is necessary in order for the final loss of energy to be effected in the tissues to be treated, for the reason that the maximum effect is induced in the cells in which *x*-rays are absorbed.

When we realize that *x*-ray energy is able to affect the subatomic structure of matter to such an extent as is manifest in the physical phenomena of ionization of gases and the production of secondary *x*-rays, it is natural to suppose that similar effects may be induced in the complex molecular structure of cell protoplasm. Such being the case, one can readily understand how functional disturbances, altered metabolism, and even destruction of cell life may result from radiation of the body tissues.

RADIUM AND RADIOTHERAPY

Attention has been called to the fact that the stability of any form of matter may be theoretically regarded as depending upon the maintenance of the proper equilibrium between the positive electric charge of each of its atoms and the combined negative charge of the negative corpuscles in each. Upon the basis of such a theory an element or a compound would, then, be *unstable* if either one or the other of these opposing forces in its atoms were in excess. Such instability might vary in degree from a very slight inequality, on the one hand, such as would require a considerable amount of external influence to bring about a readjustment of atomic structure or a change in the chemical or physical nature of the substance; while as the opposite extreme we might imagine such a considerable degree of inequality as would render the atomic structure so unstable as to permit a very slight external influence to break it up, with the result of a redistribution of units and the formation of new and stable atoms in which the opposing electric forces are equalized. As an example of a form of matter existing under the latter conditions, nitroglycerin might be cited; while such conditions as those of the opposite extreme of instability can be appropriately applied to the explanation of the origin of the emanations from radium and other radioactive elements. As stability depends upon and is influenced more or less by certain external agencies, it is regarded as possible that in some former geologic periods,—perhaps one million or more years ago,—certain coexisting conditions, such as temperature and pressure, were appropriate for the maintenance of perfect stability in these elements, which have the highest atomic weights. On the other hand, it is possible that some of the elements that are now prevalent either could not have existed or would have been more or less unstable at the period when radium was a perfectly stable element. Pursuing this

theory further, the greatly altered conditions in respect to heat and pressure of the more recent periods and the present time have been unfavorable for the perfect stability and the continued existence of these radioactive elements, hence they have been very gradually disappearing, and some of them have become extremely rare, especially radium.

Taking radium as an example, this element may have been far more prevalent in past ages, when external influences were favorable for its perfect stability, but its atomic structure, with its great mass, is such that under conditions now existent the atom is a little past the border-line of perfect stability, possibly because of an excess of negative corpuscles constituting its great atomic mass, or perhaps on account of an excessive orbital motion also. In the process of readjustment to bring about an equilibrium between the opposing forces within the atoms to suit existing conditions some one or more radium atoms are constantly expelling a number of their particles, and, as a result, this element has been and is still gradually losing its identity as radium, and has been slowly disappearing through a period of a million years or probably more, until at present it is extremely rare.

This slow disintegration of radium and allied elements is a very complicated process, and is responsible for their extraordinary property of *radioactivity*. This is strictly a property of *atoms*, arising from the spontaneous atomic disintegration of the element through the emission of portions of the structure of its atoms. The entire process represents energy, which originates from that which is inherent in the atom, possibly as an exaggerated degree of corpuscular motion. Radioactivity is manifest in the emissions, first, of certain *radiations*, which represent end-products of the process; and, secondly, of certain *emanations*, which represent new forms of matter, likewise possessing the property of radioactivity. There are three distinct types of radiations, designated as *alpha*, *beta*, and *gamma* rays. The *alpha* rays are composed of *positively* charged particles, each having a mass relatively proportionate to that of an atom, and about twice that of the hydrogen atom. These particles are projected at a very high velocity, but, owing to their great mass, they rapidly lose their energy in passing through matter, whether in gaseous or solid state, and, in fact, so much is lost in the passage through the substance itself that at any appreciable distance therefrom their energy and velocity have become so much reduced that they possess scarcely any penetration. These *alpha* particles play the most active part in all radioactive processes, but in their true identity they represent inactive products expelled at the various stages of radioactive changes, and also the final products of complete atomic disintegration. It is well known that *helium* is derived from radium, and this gas is regarded as probably identical with the *alpha* particles.

The *beta* rays are composed of *negatively* charged bodies regarded by many as identical with the negative corpuscle. They also are projected at an extremely high velocity, which is longer maintained

than that of the *alpha* particle, and they are far more penetrating relatively, though they possess but a slight degree of penetration actually.

The *gamma* rays are in many respects analogous with x-rays, and are the most highly penetrating of the radiations. They may be *identical* with x-rays, although this has not been conclusively proved.

The process of disintegration is a very slow one, because very few atoms are breaking up at one time, hence the disappearance of radioactive elements is so gradual as to require thousands of years for any loss to be appreciated by weight, except possibly in the case of a large bulk of very active radium. The process of disintegration or radioactive changes is attended by the production of a certain amount of heat, in which the *alpha* particles are again concerned, and one or all three forms of radiation are capable of ionizing gases and producing secondary rays.

This process of decay does not result directly in complete atomic destruction, but coincident with the loss of identity of the atom of the element there is a process of recovery wherein new atoms or new radioactive substances are formed by a reconstruction of the old atoms. This reconstructive process tends to establish and maintain a radioactive equilibrium, the radioactivity of the newly formed substances making up for the loss of radioactivity of the original substance through decay. The new forms of matter differ essentially in chemical properties from the original element, but are markedly radioactive, however.

The process of disintegration or decay may be briefly described as follows: The somewhat unstable atom of the radioactive element, in an effort to establish an atomic equilibrium, expels one or perhaps more *alpha* particles, whereupon the portion remaining tends to readjust its component parts in the formation of a stable atom, which represents one of the new forms of matter just mentioned. Strictly speaking, this attempt is a failure in so far as stability is concerned, but otherwise radioactivity would not amount to much. The new atom is even more unstable than the original one, and breaks up far more readily and more rapidly. In so doing it expels in its turn one or more *alpha* particles, whereupon still another new form of radioactive matter results through the reconstructive process. Thus there is produced a series of different new substances, each of which is radioactive.

Emanations.—Three of the radioactive elements—radium, thorium, and actinium—at one stage in their radioactive processes produce one of these forms of matter in the form of a radioactive *emanation*, which they are capable of emitting, but which should not be confused with their three *radiations*. This *emanation* has the properties of a radioactive gas, and will not only diffuse through other gases, such as air, but is soluble in certain liquids, especially water. This solubility permits of its collection from the gas through which it is diffused. All three of these elements just mentioned do not give off

the emanation at the same stage in their radioactive processes. For instance, in the case of thorium, the first stage of the process consists in the loss of the *alpha* particle, with the formation of "thorium x" as the new form of matter. After thorium x in turn loses its *alpha* particle, the new form of matter produced is the *emanation* of thorium. In the case of radium there is no such intermediate stage, nor intermediate product formed corresponding to thorium x, the radium emanation being produced coincidentally with the loss of the first *alpha* particle. The product resulting from the loss of the *alpha* particle from the radium emanation is designated as the emanation x of radium, or "radium α."

As the emanation is simply a reconstructive by-product in an unusual form, it is radioactive, but rapidly loses its radioactivity for the reason that it is very unstable and rapidly changes to still another substance, radium α, through the loss of its *alpha* particle. The radium emanation loses its activity or decays more slowly than does that of thorium, but it is produced in far greater quantities than is the thorium emanation. Radium α is a solid substance, but still radioactive and unstable. This is not the last stage in the series in the case of radium, but at some stage near the last the *negative corpuscles*, or *beta* rays, are expelled. It is believed that the *gamma* rays arise coincidentally with the *beta* rays, and in more or less proportionate volumes, and may be produced from the latter like x-rays. In the case of all radioactive elements it is generally believed that these two forms of radiations are produced during the last of the series of radioactive changes, and at all other stages *alpha* rays or particles alone are emitted. It is probable that the greater part of the activity of radium is really due to the activity induced through the decay of its emanation, or follows at a later stage. The emanation is always produced at a uniform rate, but is largely occluded in the compound, from which it may be removed, however, by dissolving the latter. The removal of the emanation may be further hastened by heating the solution. The liquid takes up the emanation as fast as it is produced. It may be collected from the solution by passing air through the latter, the emanation then diffusing through the air. From its mixture with air it may be condensed by extreme cold or absorbed in cocoanut charcoal. The emanation is chemically inert, and in this respect and in its high atomic weight it resembles the gases of the *argon* group.

On removing the emanation from a specimen of radium by solution, then extracting the emanation from the solution by the passage of air through it, and recovering the radium again by evaporation, the specimen will be found to have lost its radioactivity in so far as any measurements of radiation of *alpha* or *beta* or even *gamma* rays are concerned. This is but temporary, however, as after a time radioactivity will be manifest again, and will gradually increase to a normal rate after several days. So far as the radium itself is concerned, the process has been going on just at the same rate as it always did, but after removal of the occluded emanations by solution, the interval

during which no activity is manifest represents the time during which new emanations are collecting or being occluded in the specimen.

The physiologic and therapeutic effects of radium appear to be practically the same as those induced by x-rays. Excessive exposure to the radiations is capable of producing a dermatitis in no way differing from the Röntgen dermatitis. Likewise, in many instances, therapeutic results have been obtained through the use of radium equally as good as from x-ray treatment, and under certain circumstances better even than was possible through Röntgen radiation. It is a well-known fact that an individual who is entirely blind will have the perception of light when a specimen of radium is held near the eye, provided the retina be intact. This light perception may be stronger even than to an individual with sound eyes on closing the lids in a perfectly dark room. One explanation offered for this phenomenon is the fact that both *beta* and *gamma* rays are capable of producing fluorescence in the lens and retina. The eyelid when closed will absorb the *beta* rays, however, and only the *gamma* rays are able to penetrate and cause the fluorescence when the lids are closed.

As *alpha* rays represent inert by-products of radioactive processes, and have practically no power of penetration, it is probable that they possess no physiologic or therapeutic properties. While there is insufficient ground for denying that *beta* rays possess any such properties, they are certainly not sufficiently penetrating to exert any *direct* effect below the skin surface or a like depth in tissues. *Gamma* rays are undoubtedly the most important, if not the only, factors in inducing any physiologic or therapeutic effects below the surface. Just what part the *beta* rays do play is uncertain, but it is generally believed that they do exert some influence, if only indirectly, or in the production of *gamma* rays. We may, therefore, regard the action upon the tissues as depending upon the *beta* and *gamma* rays, and as these two forms of radiation in the case of radium are produced through or at a subsequent stage to the emanation, and not before its formation, the latter is really a more important factor in therapeutic and physiologic effects than the radium itself.

The most efficient method so far of employing radium therapeutically has been by direct application to the part to be treated of specimens of high activity inclosed in suitable containers. On account of the extreme rarity and great cost of this element, its use has been limited to the hands of a very few, and for these reasons attempts have been made to use the emanation instead of the specimen itself. Two methods have so far been devised for employing the emanation by extracting it and retaining it in a vehicle. The oldest is that of obtaining a solution of the emanation in water in which has been placed some weak radium or pitchblende. This so-called "radioactive water" is then administered internally or applied locally. That such a preparation possesses any real virtue is extremely doubtful, although it is probable that any curative properties inherent in the *natural* radioactive waters are due largely to the radioactive properties of emana-

tions they contain in solution. The amount of radioactivity of a natural or artificial radioactive water depends upon the quantity of emanation the latter will absorb, and as water will absorb but a very small amount of emanation, no such preparation is or can be made sufficiently radioactive to be of any practical value. Moreover, the rate of decay of the emanation in water is very rapid, hence neither natural nor artificial preparations of this kind will be active unless used when absolutely fresh.

The emanation being a gas, and because of the well-known property of charcoal for absorbing and occluding gases, the attempt was made early to use this substance as a vehicle for the radium emanation. It was found that different forms of charcoal possessed different absorptive properties for the radium emanation, wood charcoal absorbing the least and cocoanut charcoal the most, and taking up several hundred times as much emanation as water. Moreover, cocoanut charcoal will retain its radioactivity for a very much longer period than will water. Upon the basis of these facts experimental attempts have recently been made to place radium therapy upon an economic basis by utilizing this property of cocoanut charcoal. The process of its preparation is very simple. A specimen of radium salt is first dissolved in water in order to remove the emanation. Air is then passed through the solution and takes up the emanation. The air is then passed through a vessel containing the charcoal, which absorbs the emanation readily. If such a preparation can be rendered sufficiently radioactive, it is proposed to use the radioactive charcoal for either local applications or internal administration.

The efficiency of radium therapy has been sufficiently well demonstrated in connection with a number of pathologic conditions to merit a general recognition of the value of radium as a therapeutic agent. Unfortunately, however, the exceeding rarity of this element and the great cost of suitable specimens render an extensive employment of radium impossible at the present time. Its almost prohibitive cost is due partly to its rarity as an element, but far more, however, to the expense and difficulty entailed in isolating the radium compound in the first place, and its subsequent concentration in specimens of sufficiently high activity to be in any way efficient. Although specimens of low activity are comparatively inexpensive, they, unfortunately, have practically no direct therapeutic value. It may be possible, however, to eliminate the obstacle of expense by utilizing specimens of low activity in some such way as that just described.

Even were it possible to eliminate the one great obstacle of scarcity and cost, it is not likely that radium could ever equal the x-ray in *general* efficiency. Success in x-ray therapy depends largely upon the ability to properly control the various dosage factors, and even with an adequate regulation of those of time, distance, and volume in connection with the radiations from radium, it does not seem likely that the important factor of penetration can be brought under anywhere near the approximate control that is now possible with the output of

the x-ray tube. Radium has proved as efficient as the x-ray in a great many instances in the treatment of both superficial and deep lesions, and occasionally has been found even more efficient, but such cases represent but a comparatively small percentage. The one most valuable use for radium would seem to be in the treatment of lesions within such cavities as the vagina, rectum, bladder, mouth, throat, etc., where treatment by the x-ray is always difficult and usually more or less unsatisfactory, because of the inaccessibility of such localities to direct radiation, whereas radium applications may, as a rule, be readily made.

The therapeutic effect of x-ray exposure depends primarily upon two factors—varying degrees of tissue reaction that may be induced by varying intensities of radiation, and a certain selective action of the rays upon different cells. In order to obtain the desired effect in any case it is first essential to know what reaction is required to produce that effect, and, next, to administer the dosage or intensity of radiation necessary to induce that reaction. The gross manifestations of the different degrees of tissue reaction to varying intensities of prolonged direct radiation, either continuous or intermittent, are those of *stimulation*, *irritation* or *inflammation*, and cellular *destruction*. While the exact reaction will depend in general upon the dosage administered, it will vary more or less with a given dosage unit according to the selective action of the rays upon the cells. In the case of approximately healthy tissues this selective action will vary to a certain extent according to the specialization of the cells therein, being most marked, when such action is manifest, in those cells of the highest degree of specialization. This is especially noticeable in connection with epithelial structures, as may be observed, for example, in the atrophy of the glands and follicles of the skin, and alopecia, which are results of a destructive effect upon the specialized glandular epithelium, and which may follow an intensity of radiation insufficient to materially influence the vitality or functional activity of the less highly specialized cells of the skin. A still more delicate selective action is to be found perhaps in the atrophy or the inhibition of function of the spermatogenic cells of the testicle, which has been the cause of sterility, so prevalent among x-ray specialists. Actual destruction of the glandular epithelium of the skin may be produced by a comparatively mild intensity of radiation that will induce no more than a very mild stimulative reaction in the other cellular structures. In the case of more active radiation or long-continued mild exposure, sufficient to affect the other structures, the more specialized epithelial elements are always the first to suffer. When such radiation is not carried to a generally destructive stage, the changes manifest by the epidermal connective-tissue and muscle-cells are probably, for the most part, secondary to an inflammatory process induced by the exposure. Under such circumstances a somewhat distinctive change is to be noted in the smaller superficial blood-vessels, and to a certain extent also in the lymphatic vessels, especially after long-continued

mild radiation. This comprises both a degeneration and a proliferation of cells, especially of the intima, and to a less extent of the media. Proliferation is predominant, and may result in complete obliteration of the lumen of a vessel. Also new vessels may form, but are apt to have more or less imperfect walls and bleed readily. This result is often to be seen in the telangiectases that are common in skin that has received prolonged exposure, or in that covering a healed x-ray ulcer. As the formation of these vessels is coincident with the obliteration of normal vessels and atrophy of glands, such skin lacks a normal degree of vitality. Further details concerning the effects of x-ray exposure upon the skin are more intimately concerned with the pathology of acute and chronic Röntgen dermatitis, and cannot be discussed here.

In the case of *diseased tissues*, the selective action of x-rays is manifest to a considerable extent in the order of the vitality of the cells, as may be seen, for example, in the destruction of partially devitalized cells in tuberculous lesions or of malignant cells without the production of any deleterious effect upon the normal or healthy cells of the overlying or surrounding tissues. Selective action is manifest, also, to a certain extent, perhaps in the order of the approach of abnormal cells to embryonal types, as, for example, the comparatively greater destructive effect exerted upon carcinomatous and sarcomatous cells than upon those of keloids and hypertrophied scars and the distinctly benign growths.

It has been conclusively proved that radiation has little or no effect upon the vitality of pathogenic bacteria, and certainly none beyond a slight inhibitory action, whether the organisms be growing in culture-media or in the tissues. Radiation can, therefore, have little or no direct influence upon the active factors in the causation of lesions due to the invasion of pyogenic organisms and the tubercle bacillus. In the case of tuberculous lesions the bacillus is destroyed or rendered inactive *indirectly*, through the reaction induced in the tissues by the radiation. In the case of pyogenic organisms, however, the stimulative or even inflammatory reaction which is unfavorable to the life of the tubercle bacillus may in reality prove favorable to the vitality and stimulate the activity of the former. This fact should be borne in mind in any attempts made to treat pulmonary tuberculosis or caseating tuberculous glands when there is any likelihood of a mixed infection being present.

In the treatment of any condition by Röntgen radiation, at least one of the three definite reactions must be induced in the tissues in order to accomplish the desired result, and in a large proportion, if not in the majority, of the conditions treated the selective action of the rays plays an important and often an essential part. Among those conditions in which *stimulation* is the reaction necessary to effect a favorable result may be mentioned many of the skin lesions, such as chronic eczema and psoriasis; indolent ulcers; and tuberculous sinuses and ulcers. Both the object and the effect of such a reaction are to increase local nutrition and functional activity. In other conditions

a somewhat more vigorous action, corresponding to a *mild inflammatory* reaction, will be required, as in the treatment of tuberculous glands and the deeper seated sinuses and ulcers. In the treatment of those conditions in which a *destructive* action is required, the selective action of the rays may play perhaps the most important part. The destructive effect may be so slight as to do little more than *inhibit* the functional activity of certain cells, as in the treatment of acne vulgaris and hyperidrosis; or it may have to be actually destructive in a mild degree, as in hypertrichosis or other skin lesions in which epilation is the effect desired; or a decidedly destructive action may be necessary, as in the treatment of malignant growths. In the treatment of many conditions more than one reaction, and perhaps all three, may be not only manifest, but essential as well, as, for example, in lupus vulgaris, in which a destructive effect is exerted upon the cells of greatly lessened vitality, whereas a mild inflammatory reaction is necessary to indirectly destroy the organisms, while absorption and healing are promoted through stimulation of comparatively healthy cells. We regard these different effects as dependent in a large measure upon the selective action of the rays.

While we may ascribe the favorable therapeutic results in nearly all conditions either directly or indirectly to one or more of these definite tissue reactions, there are a few conditions to which x-ray therapy is applicable in which the beneficial effect of radiation is not so readily explained. In this group may be included leukemia and pseudoleukemia, in which radiation induces such a remarkable destructive effect upon lymphatic structures. Those cells which are so unusually susceptible, however, at least in the case of leukemia, represent a retrograde stage of development or more or less embryonal types. In connection with unusual effects should also be mentioned the anodyne effect so often procured through radiation in cases of neuritis, neuralgia, and pruritus, and also the relief of pain so frequently attending the x-ray treatment of malignant growths.

In order to induce any reaction, or to bring about a favorable therapeutic effect in the treatment of any condition, a certain definite *dosage* is necessary, just as in the administration of any other therapeutic agent. The amount of x-ray dosage, like that of many drugs, is often influenced more or less by certain idiosyncrasies on the part of the patient, which in the case of x-ray therapy is nearly always local. In place of such units of measurement as minims or grains, the unit of measurement of x-ray dosage is volume. This is a very complex unit, however, and depends upon four almost constantly varying factors—time, intensity, distance, and penetration. Each one of the first three of these is dependent for its value upon that of each of the others. While intensity is the least controllable of the three, it must be controlled as adequately as is possible in order to properly adjust the values of time and distance at least.

It would, no doubt, be possible in many instances to obtain the desired therapeutic effect by the administration of a single massive

dose of the definite dosage value necessary to induce the proper reaction. While such procedures are practised to a certain extent, especially by continental Röntgenologists, they are attended by more or less danger to the patient. In the first place, the same definite dosage value is by no means appropriate to all cases of any one condition; and, secondly, a definite or constant dosage value is something that is beyond the power of human control or accomplishment, because of the inconstancy of the two factors,—intensity and penetration,—and the fact that their values are always approximate only, through the lack of any means of accurately measuring or controlling them. While there are a few instances in which the administration of a single massive dose is perhaps permissible, even with only the crude and uncertain means we possess of merely approximately estimating the value of such a dose, it is much safer to follow the usual method which is practically necessary in order to derive results in most of the conditions treated by x-ray therapy, namely, comparatively short and repeated exposures, which can be kept up until the proper effect is obtained. Single massive doses are applicable only where the treatment is of comparatively short duration, as in epilation. Such a procedure is contraindicated in all cases where the treatment must be much or any longer in duration, as it is imperative that the effect be watched carefully in order to avoid an overreaction. The efficacy of the latter method, of course, depends upon the cumulative effect of radiation.

The importance of *penetration* as a dosage factor has already been explained. Unfortunately, there are no means known at present whereby penetration can be accurately measured or absolutely controlled. The most reliable and practicable devices and methods give no more than an approximate estimate of the average degree of penetration of the major portion of the output of the tube, and even this proportion of the output is a very variable quantity, especially with reference to different tubes. The output from any tube is made up of rays of widely different degrees of penetration, although the larger proportion are of nearly the same degree. Even this, however, is constantly varying to a certain extent, so that our estimation must be more or less of an average. The most reliable of the instruments so far devised for the purpose are the Benoist penetrometer and its various modifications, and the Walter skiameter. The most convenient method is that of estimating penetration by the resistance of the tube in terms of the length of an equivalent spark-gap. Although very crude, it is perhaps just as accurate or reliable as any other method, but must always be used in conjunction with the milliammeter reading.

Intensity implies the rate of delivery of x-ray energy, and should not be confused with the terms "quantity" or "volume," which apply to the product of intensity and time. Intensity is the most important factor in dosage. It is influenced by distance and penetration, and with the latter should be considered depth and density of tissues treated. Time is the factor by which we regulate intensity in order

to bring about the adequate adjustment of volume or the dosage value. Unfortunately, just as is the case with penetration, we possess no means of accurately measuring or of absolutely controlling intensity. Attention has been called to the fact that x-ray intensity, or the number of x-ray impulses produced, depends upon the number of negative corpuscles that strike the target of the tube, which in turn depends upon the volume of the exciting current available to charge them, provided the amount of gas to supply the corpuscles is properly adjusted. Therefore, with the amount of gas in the tube properly adjusted for the volume of exciting current delivered, and at the same time to permit of the maintenance of the corpuscular velocity necessary to provide the desired penetration, the amount of current passing through the tube, as registered by the milliammeter, should be an approximate index of the relative intensity of the x-ray output. The milliammeter reading may be regarded as a reasonably reliable index when intelligently used in conjunction with the equivalent spark-gap estimation of tube resistance and penetration of the output. It should not, however, be regarded as in any sense an exact means of measurement, as at best it gives but an approximate estimate of certain averages of constantly varying intensities, but it is just as reliable and as accurate as any other method yet devised, and has the advantage over all others in its simplicity and ease of application at all times. The many special devices that have been contrived, or the methods that have been suggested, depend in principle upon the estimation of intensity by comparative measurements of some one of the following effects of radiation: the color changes induced in certain chemical substances; the action upon standardized photographic papers; the extent of ionization of air; and the changes in electric conductivity induced in the selenium cell on exposure to the light from a fluorescent screen. None of these methods, except possibly the ionization method, provide for any means of estimating the comparative intensities of rays of the various degrees of penetration that the output of every tube comprises.

Distance should always be measured from the target and not from the walls of the tube, because of the great differences in the diameters of the latter. In connection with x-ray dosage, it implies the distance from the target to the patient's skin, or the surface of the part treated. The most important fact to be borne in mind in connection with this factor is that x-ray intensity, like that of light, varies inversely as the square of the distance. Doubling the distance of the target from the skin, for instance, decreases the intensity of radiation to one-fourth. Variations in volume due to differences in distance are to be counterbalanced by proper adjustments of the time factor. Another important point in connection with distance is the fact that in the treatment of deep lesions it is best not to place the tube as close to the skin as when treating superficial lesions. Of course, the nearer the tube to the part treated, the greater the intensity of radiation it receives, whether it be superficial or deep, but in the case of deep applications,

the effect is greater on the skin as well. As the tube is moved away, however, the effect on the skin lessens more rapidly than on the deeper tissues, especially at first. It is safer, therefore, when treating deep lesions, to place the tube further away than when making superficial applications, and, conversely, quicker skin reactions with a minimum effect on deeper structures are obtained by closer approximation of the tube.

Time is not only an exact factor, but, being under absolute control, is the one best adapted for adjustments to suit variations in the others. In itself it implies little as a record of dosage, but with it should always be included distance, penetration, and intensity in computing dosage records. In the treatment of any one condition, and especially in connection with applications to one individual case, the last three factors mentioned should be maintained as nearly uniform as possible, in order that the time factor may be employed as the quantitative index of the total dosage value given or to be administered.

X-ray therapy has now passed beyond the purely experimental stage; its therapeutic value is well recognized; the effects of radiation upon healthy and diseased tissues are fairly well understood; and the many dangers attending *x*-ray applications are pretty generally known. Fortunately, most of the latter can be avoided with the proper observance of reasonable care, but the careless use of this agent, or its employment without adequate training or a proper knowledge of its control, effects, and methods of administration in various conditions and in appropriate dosage, are attended with considerable risk to the patient. Therefore one who undertakes the practice of *x*-ray therapy should be adequately qualified to apply the treatment without unnecessary danger to the patients. Certain risks must frequently be incurred, even with the observance of all reasonable precautions, but in such instances the patient should be previously informed of the fact, and should express willingness to accept the risks entailed before the treatment is begun.

SPECIAL APPLICATIONS

Dermatology.—The *x*-rays have been accepted by dermatologists as one of their valuable therapeutic measures, and are now in such general use among them that the Röntgen treatment of skin diseases, with the exception of the new-growths and ulcerations, is really to be considered as much a part of dermatology as a special branch as it is a part of *x*-ray therapy in general. It is hardly appropriate, therefore, to include in this chapter more than a general résumé of the application of *x*-rays in the treatment of skin lesions. In this connection radiation should be regarded merely as an additional therapeutic agent, to be employed in certain instances as a more efficient substitute for some other *local* remedy, and wherever other, and particularly general, measures are indicated, they should be employed just as with the use of any other local application.

Technic.—In no other one group of diseases is the careful and judicious use of *x*-rays more essential than in the treatment of skin lesions, because, in the first place, successful results are so largely dependent upon the employment of the proper technic and exact dosage, and, secondly, carelessness and inappropriate dosage are more likely in the treatment of skin lesions than in that of any other of the local conditions treated to produce injurious effects—either an aggravation of the local condition itself or certain undesirable and more or less permanent evil results of excessive radiation. Although in a general way the technic is based upon the same principles that apply in the treatment of superficial lesions of any kind, in the majority of instances in which skin diseases are treated we must apply to comparatively healthy structures a dosage that very frequently approaches close to the limit of safety, in order to obtain the proper reaction. Hence the most careful measurement, adjustment, and control of the dosage factors are of the utmost importance, especially in the case of the two factors,—penetration and intensity,—whose complex and constantly varying values cannot be more than approximately estimated. It is essential that the control and measurement of both of these be as nearly exact as possible, in order that the exact and controllable factor—time—may be made to serve as the real unit of total dosage measurement.

Penetration is important, in the first place, for the reason that only by the employment of rays of a certain definite standard penetrating quality is it possible to properly estimate and adjust their intensity and volume; and, secondly, because the degree of penetration of the preponderance of the output of rays should be such that the latter will be almost entirely absorbed in the superficial structures, in order to produce the maximum effect therein with the minimum effect upon the tissues beneath. This implies the use of a tube with not only a low vacuum, but one that will maintain such a degree of vacuum uniformly throughout the entire length of the exposure, or, in other words, it must be a reliable *soft* tube. As a rule, the vacuum should be such as would show a resistance equal to that of a spark-gap of from $\frac{1}{2}$ inch, in which case the cathode stream would be visible, to $1\frac{1}{2}$ inches, with the stream just invisible, when the tube is excited by a current of $1\frac{1}{2}$ to 2 milliampères. Such tubes should not be used for any other purposes.

Distance, which should always be measured from the target to the skin surface, is especially important in superficial applications, and should always be less than under any other conditions, and consequently slight variations in distance influence intensity to a much greater extent than under any other circumstances. Close approximation of the tube is advisable for the reasons that, in the first place, the greatly increased intensity of radiation yields much quicker reactions and through shorter exposures; and, secondly, it entails less risk to the underlying structures. With the same total dosage value administered to the skin in each instance, the *proportionate* amount of

radiation that the tissues at any given depth below receive decreases as the target of the tube is brought *closer* to the surface. The basis for this statement is explained by the following table, which shows the proportionate amounts of radiation to which structures at a depth of 2 inches are subjected with the tube target at distances of 12, 10, 8, and 6 inches respectively from the skin, the latter receiving the *same dosage* in each instance through the proper adjustment of the time factor for each distance, intensity and penetration remaining constant.

Distance of Anode from Skin.	Total Amount of Dosage Received.	
	Skin.	At a Depth of 2 Inches.
12 inches.	100 per cent.	73+ per cent.
10 "	100 " "	69+ " "
8 "	100 " "	64 " "
6 "	100 " "	56+ " "

The above calculations are, of course, purely theoretic, and by no means exact, for the reasons that, first, they represent rays of only one degree of penetration, and, secondly, they do not take into account the amount of x-ray absorption between the skin and the depth of 2 inches, which would lessen the dosage still more at any point below the surface. It follows, therefore, that the softer the tube used, the less will be the ratio of the amount of radiation to which the tissues beneath are subjected, and few, if any, rays from a tube suitable for superficial treatments would penetrate to a depth of 2 inches, although a certain proportion of them would reach the tissues immediately beneath the skin.

In the large majority of skin lesions in which radiation is applicable, and in nearly all if lupus, new-growths, and nevi be excluded, a comparatively moderate dosage only should be administered, for the reason that the reactions required to effect the desired results are comparatively mild ones, varying from a slight stimulation of the skin structure, as in chronic eczema or psoriasis, to an inhibitory or, perhaps, a slightly destructive effect upon one or more of the appendages, as in acne or the removal of hair, and which is brought about through the selective action of the rays upon the more highly specialized cells or upon cells of lowered vitality. In a few conditions, mainly lupus and new-growths, a more intense reaction is required, either for the purpose of actually destroying cells of a lower degree of vitality than normal, and occasionally micro-organisms secondarily, as in lupus, or for the actual destruction of practically normal structures, such as the small blood-vessels in nevi.

X-ray treatment has been attempted in a much larger number of skin diseases than those in which its use is now generally regarded as justifiable, and only those will be considered in which its value is generally recognized and its employment advocated by conservative

dermatologists. These conditions will be grouped as nearly as possible according to the reactions required in their treatment.

(1) Conditions in which *mild stimulation* is the reaction indicated. In these the object of radiation is presumably, in the first place, to increase the local nutrition of the cells, correct a faulty metabolism, or possibly to restore a lowered vitality of the cells; and, secondarily, to promote absorption of inflammatory products and, perhaps, destroy diseased cells or those of greatly lowered vitality. In addition, the treatment may coincidentally ameliorate or completely dispel subjective symptoms in some instances.

Eczema.—Radiation should not be employed in the *acute* stage of any form of this condition, except occasionally for the relief of exceptionally severe and uncontrollable itching, which can frequently be controlled by this and no other means. The dosage under these circumstances should be exceedingly mild, and the treatment not long continued. *X*-ray treatment is not justifiable in infancy. In the *chronic* types it should never displace the older and generally efficient local agents, and its use should be limited to cases which fail to respond to these usually successful therapeutic measures. When so indicated, *x*-ray treatment often yields most satisfactory results in even the most rebellious cases. As a local measure radiation will not prove successful in those cases in which there exists a definite and discoverable direct or indirect underlying cause, such as mechanical or chemical irritation, gastro-intestinal or other systemic derangements, or disturbed local nutrition, as in leg ulcer, unless proper attention is directed toward the control of such etiologic factors. While in a general way the technic of the treatment is the same as that already described, the exactness of the dosage requires most careful attention in this condition, as it must be regulated to suit the varying pathologic features and therapeutic requirements of each case, one requiring only the mildest stimulation, while another may need the decided reaction of a first-degree dermatitis. The cases most rebellious to other methods usually require the most severe radiation, but in these the skin, as a rule, cannot stand too vigorous radiation at the start, because of its deficient vitality. The effect of the early applications, therefore, should be simply a mild stimulation, whereby the skin will be rendered capable of withstanding more vigorous treatment later on, should this be necessary. It is best, in all instances, to continue with a mild dosage until a slight erythematous reaction appears, and then to stop long enough for the full effect of the treatment to become manifest, after which it is safe to resume the applications should more be necessary. Moreover, the cells will then likely be able to stand more vigorous radiation if it seems indicated. Prolonged treatment should always be administered in several series of mild applications, or in continuous applications of greater dosage with sufficiently long intervals between to watch the full effect of each. *X*-ray treatment is particularly applicable in localized dry forms of chronic eczema, and especially in such lesions on the hands and feet. Cracks and fissures indicate a

deeper seated process, and when coexistent with the other lesions, they may require special and separate treatment.

Psoriasis.—In this condition, as in the preceding one, x-ray treatment is not generally applicable, but should be limited to selected chronic cases—moderately large single or multiple small lesions involving a comparatively limited area and rebellious to other methods of treatment. The effect of radiation is upon only the lesions exposed; it is by no means uniformly successful, and relapses are common, even after the most complete symptomatic cures. The supposed effect of radiation is the correction of faulty metabolism and abnormal cell proliferation, for which the appropriate reaction is stimulation, but more intense radiation and more prolonged treatment are usually required than is the rule with eczema or acne vulgaris. The average technic would comprise fifteen-minute applications about three times per week, using a soft tube with the anode about 10 inches from the skin, and excited by a current of $1\frac{1}{2}$ to 2 milliampères, stopping when a distinct erythematous reaction appears (usually after 8 or 10 applications), and waiting until this subsides, so that the full effect can be noted. Other lesions may be treated in the interval if present. If lesions do not seem to respond satisfactorily, it is not advisable to continue their treatment too long, as permanent damage to the skin may result.

Lichen Planus.—Selected and rebellious cases of this condition will frequently respond in a most satisfactory manner to x-ray treatment.

Alopecia Areata.—This condition has in some instances been successfully treated by radiation, which is not recommended as a routine measure, however. If used, the applications should be made with the greatest care, and no reaction beyond the mildest stimulation induced.

Leukoplakia Buccalis.—Radiation is perhaps as satisfactory a method of dealing with this condition as any other, and frequently it is the only measure to which the lesion will respond. Uniform success is not the rule, although many cases not cured may be improved. Relapses are common. The inaccessibility of the lesions is often a serious obstacle to their treatment, but in such instances it is possible to accomplish much by directing the applications from the outside, so that the rays pass through the tissues of the cheeks or lips. Should a definite underlying cause of the condition exist, the most frequent one being the use of tobacco, or at least supposedly, the removal of that cause is absolutely imperative.

Senile Keratosis.—As a rule, radiation is a very efficient means of treating this condition when its employment is indicated.

(2) Conditions characterized by *hyperactivity* or *hypertrophy* of the *glands* or *follicles*, and in which the desired effect of radiation is either an *inhibitory action* or the production of a *partial atrophy* of these structures.

Acne Vulgaris.—The invariable tendency of x-rays, through their property of selective action, to cause atrophy of the sebaceous

glands and follicles of skin subjected to moderate but prolonged exposure, and the fact that it is possible, by careful regulation of the amount of radiation, to either diminish the glandular activity or carry glandular atrophy to practically any extent that may be desired, render this agent an ideal one for the treatment of a condition such as acne vulgaris, in which the essential pathologic features of the lesions are glandular hyperactivity and hypertrophy. This ideal adaptation of radiation is borne out by the uniform success of the x-ray treatment of this condition, which has become one of the most useful applications of Röntgen therapy in dermatology. Conservative dermatologists do not, however, recommend radiation as a routine measure, but advise limiting its use to the more chronic cases, which resist simpler local and general measures. It is especially applicable and usually efficient in its results in the pustular form, in which it possesses the additional advantage of yielding admirable cosmetic results through the absorption of inflammatory exudates and the excessive scar tissue which is always more or less disfiguring in cases of this type. As a rule, the treatment of this condition is undertaken for practically no other than a cosmetic reason, hence the substitution of the disfigurement of the lesions by an equally disfiguring effect of excessive x-ray treatment is most undesirable, and the chief objection raised against radiation in acne has been the evil effects that have frequently followed its use, but largely through carelessness or inexperience. Aside from the immediate risk of dermatitis, there is the danger of carrying the atrophy of the glands too far, which results later in an atrophic skin, characterized by a dry, thin, wrinkled, and parchment-like appearance. This danger may be practically eliminated, however, by the observance of proper care in the treatment. The technic generally recommended consists in giving a series of rather vigorous applications, stopping on the appearance of a decided erythematous reaction, and waiting until the *full* effect upon the glands is manifest. Then, if the desired result has not been realized, another one or more series of applications may be given. A frequent and *dangerous* practice is to keep up a continuous series of mild applications until the desired effect seems realized, but without the production of any apparent reaction in the skin itself. Invariably, the glandular atrophy will continue after the desired effect is realized if this method be followed, and atrophy of the skin is the probable ultimate result. The hair, eyebrows, eyes, and lips should be carefully protected from exposure. Systemic conditions are often factors in the etiology of this disease, and when present, they must always be given careful attention, but no other local applications should be permitted during x-ray treatment. Radiation is also very satisfactory in the treatment of seborrheal skins with comedones.

Acne Rosacea.—While the results, as a whole, of the Röntgen treatment of this condition can hardly be regarded as satisfactory or encouraging, radiation is occasionally successful, and more often so perhaps than any other method. Its beneficial effects are practically limited to a diminution of the glandular and follicular inflammatory

process and the absorption of inflammatory products, the treatment having little or no effect upon the telangiectasis unless considerable risk of either a burn or atrophy of the skin is incurred. The best results are to be obtained, therefore, in cases in which the glandular and follicular inflammation predominates, but even in these, prolonged treatment is usually required, and its continuance in an attempt to destroy the vessels entails much risk. The proper technic is practically the same as that used in acne vulgaris.

Hyperidrosis.—Radiation is generally very efficient in the treatment of this condition, as would be expected on theoretic grounds. A few mild applications usually suffice, and a perceptible reaction is rarely necessary.

(3) Conditions in which *epilation* is the effect desired primarily, through either an *atrophy* of the follicles or a *destruction* of cells of lowered vitality.

Hypertrichosis.—In spite of its apparent theoretic adaptation, radiation is neither a satisfactory nor a successful method for the *permanent* removal of *healthy* hair. In order to effect permanent epilation in this condition it is necessary to produce either partial or complete atrophy of the comparatively healthy follicles, which implies a similar effect upon the associated sebaceous glands. In any instance, success is impossible without a very close approach to the limit of safety, and while results have occasionally been successful, they are uncertain and unreliable if the treatment be kept well within safe limits. While rather extensively employed abroad, conservative American dermatologists do not regard radiation as justifiable in the treatment of hypertrichosis, except in an occasional case, for special reasons.

Sycosis; Favus; Tinea Tonsurans.—In the *x*-ray treatment of these conditions, epilation alone is the desired effect of the radiation, which is an admirable, efficient, and painless method of removing the hair in order either to give good drainage or to permit a more prompt and certain action of other local applications, or both. For this purpose, a moderate dosage is all that is required to destroy the partially devitalized cells, and the treatment is attended by no risks if it be stopped as soon as the hairs begin to come out readily, but a further continuance may aggravate an inflammatory process. Radiation has no effect upon the organisms directly.

(4) New-growths.

Lupus Vulgaris.—This was the first condition to be successfully treated by radiation, which has now become generally recognized as a specific therapeutic agent capable of absolute control over what was formerly regarded as a dreaded disease. Perhaps more credit is due to Finsen in this connection for his successful efforts directed especially toward the elaboration of another method, equally as efficient, than to Röntgen. Phototherapy is perhaps just as efficient as radiation in the treatment of lupus, but this statement is applicable to the use of the Finsen lamp only, or its direct modifications, and not to the num-

erous other lamps which, if efficient at all, are effectual in the more superficial cases only. It is now generally conceded that x-rays are not only equally as efficient as light, and more so in the deeper seated lesions, can be used satisfactorily, as a rule, in cavities such as the mouth and pharynx, are less expensive, much less troublesome to both patient and operator, yield somewhat quicker results, on the whole, and the exposures require much less time, the extent of the lesion making no difference in the length of the application, as is the case with the Finsen method. Radiation must, therefore, be given preference over the Finsen treatment. Failures are not infrequent, but arise from two well-recognized sources—errors in diagnosis, in which syphilitic lesions are mistaken for lupus, and insufficient or improper treatment. A more severe reaction is required than is the case with any of the foregoing conditions. It is advisable to obtain a decided visible reaction early in the area of the lesion, and to maintain it until the disease is eradicated. The desired effect of the reaction is, first, a *stimulation* to increase the vitality of the cells that are not distinctly diseased, and to increase the local nutrition, in order to create conditions unfavorable to the life of the organism; to promote the absorption of inflammatory products and those of cellular destruction; and, later, to promote the proliferation of connective-tissue cells and favor cicatrization; and, secondly, a *destruction* of the diseased cells. Either method yields the most satisfactory cosmetic results. Ulceration may be avoided, as a rule, and it is advisable to avoid it, when possible, because of the discomfort and trouble it entails, but the production of ulcers should not be allowed to modify the treatment to any great extent. Ulceration simply means that the process of destruction is in excess of that of repair.

Lupus Erythematosus.—Absolute permanent cures of this condition by radiation are not only rare, but their possibility is questionable. Improvement may be expected, however, in a fair proportion of cases, but in many no benefit will be derived. As this disease is so very rebellious to all other forms of treatment, it is safe to say that, on the whole, the results under radiation have been more satisfactory than with any other methods, with the possible exception of the Finsen light. The necessarily prolonged and severe radiation required entails a considerable amount of risk from x-ray ulceration or atrophy of the skin. The proper technic is one similar to that employed in acne rosacea. It is advisable to try the effect of moderate treatment within perfectly safe limits at first, and, failing in that, the advisability of more severe treatment may then be considered, especially from the standpoint of the risks. In very obstinate cases it is not advisable to attempt the removal of the telangiectases. In some instances better results have been claimed with the Finsen light than with radiation. The former is certainly attended with less risk.

Mycosis Fungoides.—This condition has been successfully treated by radiation in some instances.

Warts.—Simple warts may be destroyed by radiation, but instances are exceedingly rare in which excision, freezing, or cauterization are not far more preferable, as well as quicker.

Keloid; Epithelioma; Paget's Disease.—Detailed discussion of these conditions is hardly appropriate here, as their treatment is more closely allied with surgery than with dermatology even. Radiation is undoubtedly the best treatment for keloid known at the present time. It may be employed with or without operation. In the usual seat of Paget's disease—the breast—the advisability of employing *x*-ray treatment is always to be questioned.

(5) Conditions in which the *destruction* of *blood-vessels* is the effect desired.

Nevus.—With a few possible exceptions, *x*-ray treatment of this condition should be limited strictly to the simplest pigmented cases and the one vascular type commonly known as the "port-wine stain," and only in selected cases of these types should it be employed. In order to cause obliteration of the smaller vessels the effect of the radiation must be somewhat similar to that in the chronic *x*-ray dermatitis of the *x*-ray operator, although the exposure is more severe while it lasts, and is of much shorter duration, a constant perceptible reaction being kept up throughout. Such skin is more resistant than normal because of its excessive supply of blood-vessels. For this reason particularly there is risk of atrophy of the skin or late *x*-ray ulceration resulting. Perfect cosmetic results should not be expected or even attempted, the most that should be hoped for being an improvement in the appearance. The treatment should not be attempted during infancy.

(6) Miscellaneous conditions.

Pruritus.—Radiation is a very useful agent in dealing with this condition, but is a measure that should, as a rule, be employed more as a last resort. In this connection many of the most intractable cases of pruritus vulvæ et ani will be found to yield most satisfactorily to a few *x*-ray applications of comparatively moderate dosage. This peculiar action of radiation is, no doubt, somewhat analogous to its analgesic effect, so often obtained in the treatment of obstinate neuralgia and in the palliative treatment of malignant growths. The reaction resulting from the amount of radiation usually needed in the treatment of pruritus and neuralgia is no greater than a mild degree of stimulation, as a rule, and insufficient to produce a distinct skin reaction.

Herpes Zoster.—In many instances radiation has proved very efficient in lessening or completely relieving the severe pain attending this condition, and has even shortened the course of the lesions to a certain extent—possibly through stimulation and the correction of faulty metabolism and the promotion of absorption. It is by no means uniformly successful, however, and may even aggravate the condition. Only mild dosage should be administered.

Infectious Diseases.—The only diseases belonging to this group

to be discussed from the standpoint of x-ray therapy are pneumonia, leprosy, and tuberculosis.

(*a*) *Pneumonia.*—This condition is mentioned more for the purpose of calling attention to certain dangers from x-ray exposure than for any therapeutic properties possessed by this agent in the treatment of the disease. Some careful experiments carried out upon cases of unresolved pneumonia have shown that x-rays may act upon the leukocytic exudate in the lungs in a manner somewhat analogous to their action upon the lymphatic enlargements in leukemia. Moderate radiation of the chest in such cases has been followed by rapid resolution, which has been attended by a marked increase in the elimination of waste tissue products by the kidneys—notably that of nitrogen and the chlorids. Experimental and practical applications in a few cases of unresolved pneumonia have not only shown that radiation may sometimes, but with great care, be employed to advantage in clearing up cases of unresolved pneumonia, but they have also strongly suggested the possibility of x-ray exposure for any purpose, and especially in fluoroscopic examinations, being attended by considerable unnecessary risk during the acute stages of the disease through the production of an overwhelming toxemia arising from the rapid destructive effect of the rays and the resulting sudden liberation of excessive quantities of waste tissue products.

(*b*) *Leprosy.*—This disease is mentioned mainly to call attention to the fact that radiation has been given a comparatively extensive trial in the treatment of its lesions. The results have been generally unsuccessful, but some rather recent experiments made in the Philippines would seem, if the reports be reliable, to offer some hope of radiation being employed to some advantage in the treatment of leprosy. A small percentage of cases have been reported as apparently cured, at least temporarily so, while improvement in local lesions has been claimed in a larger number, although in the majority of cases treated practically no effect has been produced. In order to exert any influence whatever upon the lesions it seems necessary to produce an intense reaction comparable to a decided "burn." Cases with prominent or elevated localized lesions are said to respond best, while in those with diffuse skin involvement, or lesions that are atrophic in character, no apparent benefit has been derived. It is claimed that the production of immunizing substances through the destruction of the organisms in the lesions exposed is an important factor in controlling the disease.

(*c*) *Tuberculosis.*—Radiation has become invaluable in the treatment of many of the manifestations of this disease, while in others it possesses little or no value. Whatever the nature or the location of the lesion treated, the tissue reaction induced by the radiation must produce three definite effects in order to bring about a satisfactory result. First, it must induce conditions that are unfavorable to the existence of the tubercle bacillus, as radiation, unlike light, exerts no direct influence upon the vitality of this organism. The ***general***

tissue reaction required for this purpose may vary from a mild stimulation to one that is more or less inflammatory in degree. It is supposed that the hyperemia so induced increases the nutrition and vitality of the cells to such an extent that their resistance to the organisms is increased, or they are enabled to actually destroy the bacillus. It is possible that, in addition, the *x*-rays exert a direct stimulating effect upon the cells themselves. Secondly, the same dosage may be destructive to the diseased cells whose vitality and resisting powers are greatly lessened. Thirdly, the radiation should promote the absorption of exudates and the products of destruction. Fourthly, stimulation should be further effectual in promoting connective-tissue cell proliferation and cicatrization. As a rule, the best results are to be obtained in those lesions and in those localities in which an appropriate *x*-ray dosage can be administered with the greatest degree of exactness, namely, in the more superficial manifestations, such as lupus vulgaris, tuberculous ulcers, verrucose dermatitis, adenitis, laryngitis, peritonitis, and orchitis. The treatment is less successful or entirely ineffectual, on the other hand, first, in those lesions and localities in which dosage is less under adequate control or cannot be sufficient on account of the depth or danger to the skin, as in bone and joint or kidney manifestations; secondly, where avenues of reinfection persist and tend to prevent at least ultimate success, as in laryngitis; or, thirdly, where the process is usually too active to be influenced by radiation, as in many pulmonary lesions and meningitis. Where mixed pyogenic infection coexists, as in the early suppurative stage of adenitis and in pulmonary lesions under like conditions, the tissue destruction that is already under way is apt to be hastened and extended, and, as a rule, *x*-ray treatment should be withheld in such instances, at least until suitable conditions prevail for its use.

In every instance radiation should be regarded and employed strictly as a *local* measure, and in *conjunction with* such of the generally recognized essential constitutional measures as may be indicated. In those manifestations in which it is not usually successful, radiation should never supplant other more uniformly successful local measures, such as rest and surgical procedures in bone and joint lesions, for example. Careful attention should always be given to the closing of all avenues of reinfection, such as the mouth, teeth, or throat, in cases of cervical adenitis. Finally, undue credit should not be given to radiation where it may apparently have been successful in the treatment of conditions in which it seldom succeeds, for the reason that *nature*, aided or unaided by general measures, usually deserves all the credit under such circumstances.

Tuberculous Adenitis.—Aside from lupus vulgaris, this is the most important application for *x*-ray treatment among all the manifestations of tuberculosis. It is not generally applicable to all cases as it is in lupus, however, and is of value in the treatment of superficial glands only. Three distinct types of cases should be considered from the standpoint of *x*-ray treatment: (1) Those with distinctly palpable

but only moderately enlarged glands, that have scarcely or perhaps just about reached a size for operation to have been indicated in former years. In this type radiation is nearly always successful in effecting a cure and avoiding a tedious operation, and the resulting scar, in the case of the neck. Recurrences, though not the rule, simply call for a repetition of the treatment. (2) In cases in which there are one or more large glands that have considerably passed the operable stage in size, but show no signs of suppuration, radiation alone may be successful, but it is perhaps more conservative to excise the one or more large glands and leave the smaller ones to postoperative x-ray treatment. In this way the operation itself may be much simplified, and there is far less likelihood of recurrence. Large glands not only require prolonged x-ray treatment, but are often the seat of mixed infection, even before any signs of suppuration may be apparent, in which case radiation is likely to hasten the suppurative process. (3) Cases with large caseating glands, with or without sinuses, are primarily surgical, but postoperative x-ray treatment is indicated in these cases for the same reasons as in the preceding type, and it has the additional advantages of hastening the healing of sinuses or ulcers and of greatly improving the cosmetic results. The application of the routine general measures and careful attention to all avenues of mixed or reinfection, such as the nose, throat, tonsils, and teeth, are perhaps even more essential in connection with the x-ray treatment of adenitis than with any other manifestations of the disease. Any local applications to the skin other than radiation during the use of the latter are *dangerous,* and should be prohibited. The treatment must be carried to the point of a decided but safe skin reaction in order to be successful, and in the case of the neck especially the skin should receive careful attention during the treatment, and the use of an x-ray filter is advisable.

Recent experiments have shown that radiation is capable of raising the opsonic index to the specific organism in a few of the conditions of bacterial origin that are amenable to x-ray treatment, especially tuberculous adenitis, lupus vulgaris, and acne vulgaris. Observations made in a number of cases of tuberculous adenitis successfully treated have shown that the opsonic index to the bacillus is maintained at a high figure during the progress of the treatment, at least as long as the organisms are present in the lesions exposed. This effect of radiation conforms with and perhaps explains the phenomena frequently observed in the coincident tendency of a group of tuberculous glands in one locality to subside without any exposure during the treatment of another group in another part of the body. It is also possible that the immunizing substances produced as a result of the destruction of bacilli in the lesions treated may have much to do with the further destruction of the organisms in those same lesions.

Tuberculous Laryngitis.—Radiation is a valuable measure in the treatment of this distressing condition, but far greater care and much less exposure are required in the applications than in the treatment of

any of the other manifestations, except possibly peritonitis, for the reason that overreaction is readily induced and is certain to aggravate the condition, or at least the discomfort. Permanent cures are hardly to be expected as long as a constant source of reinfection, usually the lungs, persists, but careful radiation will often heal the lesion, temporarily at least, though even when not so successful, it will usually relieve the discomfort either entirely or to some extent, in even hopeless pulmonary cases. Restoration of function is always uncertain.

Pulmonary Tuberculosis.—The x-ray treatment of this condition can hardly be regarded otherwise than experimental from a conservative standpoint. The majority of the numerous reports of cases of pulmonary lesions healed while under x-ray treatment are no doubt true in a sense, but that radiation was the direct curative agent in any one of them is very questionable. Probably any benefit derived from radiation has been solely through its service as an adjunct to the far more efficacious general measures coincidentally employed, either intentionally or unintentionally. A case that gets well while under x-ray treatment in such a locality as Colorado would probably not be benefited in the least if treated in the same manner in one of the cities of the North Atlantic States. Radiation is more likely to do harm than good in cases with mixed infection.

Tuberculous Peritonitis.—Radiation has frequently been used to advantage in this condition, but it should always be applied with caution. It should never be given preference over operation in the ascitic type, but is well worth trying as a postoperative measure in any case in which laparotomy and drainage are unsuccessful. It is less likely to do good in the plastic variety, but considerable relief from distress and, rarely, even a symptomatic cure, may be obtained in these otherwise unfavorable cases.

Bone and Joint Lesions.—Any favorable claims made for radiation in the treatment of these manifestations are, for the most part, entirely unwarranted. Any apparent cures that have followed its use have undoubtedly been dependent largely or entirely upon other local or general measures, and the lesions would have healed just the same without any x-ray treatment. In many instances dermatitis has resulted from prolonged and useless exposure. The treatment can hardly be regarded otherwise than as purely experimental.

Tenosynovitis.—Radiation has occasionally yielded very satisfactory results in the treatment of this manifestation.

Cystitis.—In a few instances the use of radiation as an adjunct to other measures has apparently been attended by some benefit, but too much credit should not be claimed for the x-rays in such cases.

Orchitis.—Radiation may sometimes be employed to advantage as a postoperative measure, or in advanced cases with sinuses when castration is refused. Sterility is to be expected, but is not a contraindication under the circumstances.

Pyonephrosis.—Nothing is to be gained by x-ray treatment in this manifestation.

Diseases of the Blood.—*Leukemia.*—Aside from the comparative infrequency of this disease, its treatment constitutes one of the most valuable therapeutic applications for radiation. The first authentic report of a case of leukemia treated in this way was made by Pusey, in 1902, and, so far as is known, the x-ray treatment of this disease had its origin in an unsuccessful attempt to reduce the splenic enlargement in a case of the splenomyelogenous type through direct exposure over the spleen. Although Schultz is credited with having obtained a symptomatic cure in a case in 1901, Senn was probably the first to formally report such a successful result in 1903. During the few ensuing years reports of symptomatic cures were frequent, and it was believed for a short time that in the x-rays had been found a successful means of combating this previously incurable disease. It was soon discovered, however, that all cases that had responded favorably relapsed sooner or later, and ultimately died, and that all that could be claimed in favor of radiation over the therapeutic measures previously employed were a somewhat greater certainty and uniformity of symptomatic improvement, followed by variable periods of quiescence, and a longer expectation of life.

For a number of years the practice was continued of directing the exposures primarily over the region of the enlarged spleen in the splenomyelogenous type, and over the other lymphatic enlargements in addition in the lymphatic variety of the disease. While in many instances the bones in certain localities, notably in the regions of the sternum and the knees, received some attention, their exposures were made in a more or less perfunctory manner, and were insufficiently prolonged or wide-spread to exert any definite influence upon the bone-marrow, which was regarded as of secondary importance, or its exposure not at all essential. Under this method of treatment the number of ultimate cures actually claimed has been less than 10 per cent., but it is really questionable whether any case of leukemia can be regarded as having been *permanently* cured by radiation. The utter lack of conformity of the ultimate results of x-ray treatment with the very promising primary effects, as a rule, obtained, together with our knowledge of the profound influence of radiation upon the lymphatic tissues of leukemics, would certainly suggest that the method hitherto employed in treating the disease has not been such as to yield the best results that may be possible. One striking fault in the method is suggested if we but carefully and seriously consider the modern views concerning the pathology of this disease. If we are to regard the *bone-marrow* as the primary focus of the disease, and the lymphatic enlargements as secondary or metastatic foci, it would certainly seem plausible that the treatment, as hitherto carried out, has been directed largely toward the wrong structures, and that a more rational procedure would be to direct the applications primarily or most energetically against the primary foci in the bone-marrow.

The frequent apparent symptomatic cures, with subsequent periods of quiescence, that have followed the older method of treatment, may

be readily explained by the facts: First, that radiation of the spleen and other lymphatic enlargements primarily destroyed certain cells in those structures directly, thereby diminishing their size; and, secondly, as a result of this destruction, leukolytic substances were produced and liberated, and these had the property of destroying large numbers of leukocytes in the blood, thereby reducing the leukocyte count; and, thirdly, these substances also exerted more or less of an inhibitory effect upon the proliferation of new cells by the bone-marrow, which was only temporary, however. Directing the treatment to the primary foci in the bone-marrow would certainly seem to be a much more direct way of reaching the cause, and the clinical results have unquestionably proved this to be the more rational method. In addition to exerting a more powerful inhibitory influence upon new cell-proliferation, we are doubtless able at an earlier period to prevent continued metastasis of new cells to the spleen and lymph-glands. A cure of the disease implies a permanent elimination of the cause of the new cell-proliferation by the bone-marrow, the possible accomplishment of which is at present still purely problematic. Clinical experience has shown that applications to the bones alone will usually, but not always, cause a diminution in the size of the splenic and lymphatic enlargements, without any direct exposure of these structures, and this is a distinct advantage for the reason that dangerous toxemias are very apt to follow the early exposure of these large accumulations of extremely susceptible cells, and in a number of instances such a toxemia has been sufficiently overwhelming to produce death. By employing the bone-marrow treatment, the exposure of the metastatic foci may be left until a time when these structures have diminished to a size and the leukocyte count decreased to a point where the direct exposure of the former is comparatively safe, and the patient's general condition has improved to such an extent as to enable him to stand the effect better. Another but less important advantage of the newer method is the lessening of the risk of producing a "burn" over the splenic area. The subsidence of lymphatic structures without direct exposure, and especially that of the spleen, is very apt to raise the leukocyte count, which is likely to remain high, while the subsidence continues. This should not be mistaken for an indication of failure of the treatment, as has been done in some instances.

The *technic* of the bone-marrow treatment is a matter that requires very careful attention. Exact dosage measurements are most important, and especially in the early period, when toxemias, which are always undesirable, are especially apt to be produced. Any evidences of toxemia are indications to decrease the dosage, proceed cautiously, and avoid exposure of the metastatic enlargements for some time. In order to succeed, the exposure of the bones must be carried out thoroughly and systematically, and the entire body should be divided into several definite areas, each of which should be exposed equally and with regularity, but those including lymphatic enlargements and the region of the spleen should be carefully avoided until a safe period is

reached for the direct exposure of these structures, which will depend upon the circumstances attending each individual case. The *frequency* of the applications is also a matter of importance. Daily applications, when possible, are advisable, because not more than one area should be exposed at a time, until late in the treatment, at least, but each should be exposed several times (at least three) in succession, so that by the time the entire body has been covered, the effect of the previous applications on any part may not be partially or entirely lost by the time its turn comes for another series if the treatments are too far apart. While the *duration* of the entire course of the treatment is a matter of extreme importance, it is one that is rather difficult to define. It will, of course, vary considerably in each case, but probably in no instance can any lasting benefit be expected from less than 100 applications, and usually many more than this will be required. Too early a cessation, before the cause is rendered as inoperative as possible, not only precludes the possibility of a cure, but insures a relapse sooner or later, and, as is well known, each succeeding relapse responds less favorably. Experience has proved that to obtain any adequate control over the primary foci of the disease requires prolonged treatment over a long period of time, hence a comparatively rapid symptomatic cure, such as is apt to result from the older method of treatment, renders ultimate failure all the more certain. It has been proved in practically every case ever treated that a normal leukocyte count, a disappearance of splenic and lymphatic enlargements, and an apparent return to normal health and vigor have not been sufficient, and one should not be satisfied to stop treatment until normal ratios have been established in the differential leukocyte count. By continuing until such a result is attained we certainly approach more closely to a cure, and, subsequently, by closely watching the differential count and beginning a series of applications over the entire body on the first sign of any decided reversion of the differential count to previous ratios, taking this as a forerunner of a relapse, not only may the latter be warded off for a longer time, but far less treatment will be required than for a definite relapse. In order to watch the effect of each application it is advisable to make a leukocyte count either just before or after each treatment, especially the earlier ones, but too much importance should not be placed upon the leukocytosis, as it is of only secondary importance, and by no means accurate, as an index of the patient's condition. Differential counts should also be made frequently, as they give a far more accurate knowledge of the effect of the treatment upon the disease. Long intervals of rest during the active period of the treatment are inadvisable.

The *ultimate prognosis* under *x*-ray treatment must continue to be regarded as unfavorable, and even should it be any better under the new than with the old method, permanent cures, should they be possible at all, must continue to be very exceptional, for the present at least. We must continue, therefore, to regard radiation as a palliative measure, even though it be the only rational method of treating

this disease. Of the two methods of *x*-ray treatment, the newer one undoubtedly promises a longer expectation of life during a period of comparative comfort. A noticeable early and progressive improvement in the general condition is characteristic in cases that respond favorably, and even in the less favorable cases it is not uncommon for a patient to regain an apparently almost normal state of health and degree of vigor, even with the leukocyte count quite high and the secondary enlargements nearly of the same size as in the beginning. All cases do not respond, and even some that would be expected at the start to progress favorably. *X*-ray treatment may be regarded as contraindicated in acute cases, whether in the primary stage or during a relapse, and also in those in which evidences of a profound toxemia are manifest, for not only is no benefit to be derived, but it is quite possible that even mild radiation may shorten life in such cases.

Careful attention should be given to the examination of the urine, especially in cases in which the treatment tends to induce toxemia. There is practically no direct danger to the kidneys if toxemia is avoided. The use of arsenic or any other agent or measure having a tendency to destroy leukemic cells should not be permitted in conjunction with *x*-ray treatment, unless administered with extreme care and with full appreciation of the double destructive effect thereby produced.

Pseudoleukemia.—Radiation is likewise the only rational method of treating this disease known at the present time. The effects produced by *x*-ray treatment in this condition differ essentially in many respects from those noted in leukemia. In the first place, Hodgkin's disease must be treated as a local and not as a general condition, the effects of the applications being exerted in only the local enlargements exposed. While the direct effect upon the local enlargements themselves may be much the same as on those of leukemia, any leukocytic substances that may possibly be produced thereby do not, so far as is known, exert any influence upon the disease itself or upon the lesions elsewhere than in the area exposed. The elimination of waste tissue products is about proportionate to the amount of destruction of the enlargements exposed. The destructive effect follows the rule of that upon lymphatic tissues, being manifest much earlier, as a rule, than is the case with other growths, like sarcoma. This is an important fact to bear in mind, as evidences of toxemia may be manifest a few hours after an application that is too severe. Toxemia is apt to follow the first few treatments in any case.

From the standpoint of the effects of *x*-ray treatment, at least three distinct types of the disease may be recognized: one in which the enlargements will subside with comparative rapidity and may disappear after a very few applications; another in which the subsidence is slow, but progressive, this being the most frequent variety; and a third type, in which the applications seem to exert little or no influence toward diminishing the enlargements. Otherwise, the prognosis is largely dependent upon three features: the distinct localization of the enlargements; the extent of their distribution, when not localized;

and their accessibility. Mediastinal, retroperitoneal, and intrapelvic enlargements are the least favorable from the standpoint of location, for the reason, first, that they are the least accessible, and, secondly, because the progress of their treatment cannot be observed satisfactorily, and as a result they are seldom treated long enough.

The technic of the treatment is based upon much the same principles as that of malignant growths, and it is just as well to regard the enlargements as of such a nature and to treat them accordingly, not stopping the applications until all palpable glands have disappeared. Toxemia and, especially, severe headache are apt to follow the earlier applications, which should, for this reason, be much less vigorous than the later exposures. When enlargements are widely distributed, it is advisable not to expose more than one area at a time at first.

As to the prognosis in general, three distinct results are possible. Permanent cures may be regarded as possibilities far more likely to be realized than in leukemia. The proportion of such results is certainly not over 20 per cent., and probably not much, if any, over 10 per cent. In the majority of cases suitable for treatment, and which respond thereto, at least a very considerable prolongation of life may be expected, before the patients ultimately succumb after repeated relapses, and even in the majority of mediastinal cases life may be prolonged during a period of many months or years of comparative comfort through the temporary relief from pressure afforded. In cases with cervical and axillary enlargements it is wise to consider the possibility of mediastinal enlargements as well, and to expose the chest thoroughly, as many such cases have ultimately died from the effects of intrathoracic manifestations after the entire disappearance of the superficial ones. In a certain proportion of cases, but fortunately the minority, *x*-ray treatment seems to exert little or no influence toward controlling or diminishing the enlargements, even in some cases that might be expected to respond most favorably.

Polycythemia.—A more or less prolonged temporary improvement in the general condition and slight reduction in the number of red blood-corpuscles seem to be about all that can be accomplished by the *x*-ray treatment of this disease. As in leukemia, the direction of the applications toward the bone-marrow as the primary seat of new cell-proliferation, rather than to the spleen, seems to be considerably more effectual.

Splenic Anemia.—*X*-ray treatment has been rather extensively tried in this condition, but the results have so far not been encouraging. The applications seem to have been restricted to the spleen. Slight temporary improvements in the general condition and the anemia have been noted, but there has been little or no attendant reduction in the size of the spleen, except in a very few instances.

Pernicious Anemia.—*X*-ray treatment in this condition, on the one hand, cannot be regarded otherwise than as experimental, and, on the other, while it has been apparently beneficial temporarily in some instances, it should be looked upon as dangerous and unjustifiable

in the majority of cases. There are a few recorded instances of patients with decided toxemia having been exposed to radiation one or more times with direful results, the toxemia in some of them having been aggravated to such an extent as to have apparently hastened death. It is decidedly unsafe, therefore, to employ radiation in such cases, and, if used at all, its application had best be strictly limited to such cases as are not distinctly toxic and do not respond to other methods of treatment. Even in these, extreme caution should be observed in its application, using a very moderate dosage at the start, and watching carefully the effect of each exposure.

Ductless Glands.—(*a*) *Elephantiasis.*—While there have been a few reports of satisfactory results following radiation in this condition, it is one in which such treatment is but rarely applicable, as, for example, where the action of the *x*-rays in reducing lymphatic glandular enlargements is likely to promote the desired result. No benefit could be expected in cases of advanced elephantiasis of filarial origin.

(*b*) *Goiter.*—The results following the *x*-ray treatment of goiter seem to vary considerably in the hands of different Roentgenologists, hence it is only natural that the views of clinicians and surgeons regarding the efficacy of radiation in exophthalmic goiter should likewise differ, and that many of them should hesitate to regard with favor a therapeutic agent that yields such variable results in the hands of those who employ it. While many Roentgenologists not only claim uniformly good results from radiation, but are able to substantiate their claims, there are many others engaged in *x*-ray work who have had little or no success. There are two apparent reasons that may be advanced to explain this difference in results. In the first place, it is a noteworthy fact that those who have been the most successful and who urge the *x*-ray treatment of goiter the most enthusiastically are those Roentgenologists who have had considerable experience in this method of treating thyroid enlargements; and, secondly, they will not, as a rule, consent to undertake the care of a case unless they are assured beforehand that the treatment will be given a fair trial, while, on the other hand, it is quite likely that nearly if not quite as many failures in the hands of others are the result of experimental or insufficient treatment as of inexperience.

Exophthalmic Goiter.—All Roentgenologists who have been successful in the treatment of thyroid enlargements are united in the opinion that this type of goiter is the one best suited to *x*-ray treatment, and certainly there are far better scientific and theoretic reasons for employing it in this type than in either simple or cystic goiters. The essential pathologic feature in Graves' disease is an exaggerated secretory function of the thyroid rather than glandular hypertrophy, and to the toxemia arising from this hypersecretion are the characteristic symptoms of the disease largely due. One of the early and essential physiologic actions of prolonged radiation upon glandular structures, and which almost invariably precedes atrophy, is an inhibition of glandular activity. This action is the basis for the use of

radiation in exophthalmic goiter, the desired effect being an elimination of the symptoms due to the hyperthyroidism. According to the experience of most successful Roentgenologists, radiation is especially well adapted to the treatment of those cases in which hyperthyroidism is especially marked.

Thyroidectomy has been a generally successful method of dealing with Graves' disease in the past, and the only reason for giving any important consideration to x-ray therapy is the fact that this operation is, unfortunately, attended by certain well-recognized undesirable features, the worst of which is a distinct mortality. Should x-ray treatment be made uniformly successful, it would be a most desirable method, as the death-rate attending its use would be practically nil, and the only danger to be associated with it, aside from the "burn," is the slight chance of carrying the inhibitory action upon the gland too far, which is hardly worth considering except when the treatment is intrusted to inexperienced hands.

On the reliable authority of those who have been successful in this treatment, the results are manifest comparatively early in those cases which do respond. The extreme nervousness and tremors usually subside first, followed by the palpitation and dyspnea, and later by a material lessening or even entire disappearance of tachycardia and exophthalmos. Although some glandular enlargement, exophthalmos, especially if very marked at first, and some tachycardia, on exertion, usually persist, for some time at least, the really distressing and important symptoms are practically eliminated, and the results are usually permanent. It is a useless waste of time and trouble to undertake x-ray treatment unless it can be given a *fair trial*, which implies that it should be persisted in energetically for at least *three months* before being given up, although this is a much longer time than is usually required in cases that respond satisfactorily. The shorter the duration of the disease, the more favorable, as a rule, is the prognosis. Radiation possesses the advantage of being just as applicable in cases in which nervous symptoms are marked, while under such circumstances operation is less desirable.

The use of the proper technic is the one secret to success. It is essential to treat all cases as vigorously as possible, especially at first, pushing the dosage to the limit of safety to the skin, and in order to permit the latter to stand the greatest possible amount of exposure, x-ray filters should always be used, as well as other prophylactic measures against dermatitis. The application to the skin of any substances whatsoever of an irritating character during the x-ray treatment should be strictly prohibited, and their use inadvertently calls for an immediate cessation of radiation. The more severe the nervous symptoms, the more energetic the treatment required. The gland should be exposed systematically in all directions, except from the back, of course, using a tube giving sufficient penetration to reach the deepest portions of the structure. At first the applications should be made almost daily until it is advisable to stop on account of danger

to the skin, and then, after waiting long enough for the reaction to subside, another series of exposures should be given in the same manner as before, except with somewhat less frequency. It is always advisable to make the applications in series with periods of rest intervening, not only because it is safer for the skin, but also for the purpose of avoiding an excessive inhibitory action upon the gland, just as in the treatment of acne. The technic is much the same as that employed in the treatment of tuberculous adenitis. Relapses, though not common, simply call for further treatment.

At the present day many surgeons, when time and other circumstances permit them to do so, make it a practice to submit their cases to a course of antioperative x-ray applications, with a view, mainly, of diminishing to a certain extent the hyperactivity of the gland, especially in cases with exaggerated nervous symptoms, and also for the purpose of taking advantage of the possible tendency toward the development of a firmer capsule, because such an effect, if really produced, would tend to prepare the case better for operation. Contrary to the claims of many, the amount of capsular thickening so produced could hardly be sufficient to add in the least to the difficulties of the operation.

No conservative Roentgenologist claims that radiation is likely to succeed in every case, but there is sufficient proof of its efficacy in general to warrant a fair trial in any case in which it may be desirable, and should it not prove successful, operation still remains.

Cystic Goiter.—The effects of radiation upon this type of goiter are so comparatively slight in even the most favorable cases that x-ray treatment is seldom worth considering. It may accomplish something, however, and may be used for what it is worth should this seem desirable. The first and practically the only definite effect of prolonged radiation is the checking of further hypertrophy of the gland. Any further effect consists solely of a thickening of the capsule and more or less increase in the stroma, with possibly some thickening of the walls of the smaller blood-vessels, all of which are an aid in a subsequent operation rather than a hindrance, as is often claimed as an objection against antioperative radiation. In order to materially reduce the size of the gland, absorption of the cystic contents is necessary, and nature, not radiation, is the sole agent through which this can be brought about.

Simple Hypertrophic Goiter.—The results of x-ray treatment of this type are far more satisfactory, and much can be accomplished by radiation, especially in the moderate sized goiters in children and young adults. A material and permanent reduction in size, and not a complete disappearance of the enlargement, is all that should be expected, however.

Constitutional Diseases.—*Gout.*—Radiation is practically of no value in the treatment of this condition. Experimental metabolism investigations have proved that the direct exposure of extensive gouty deposits exerts no influence toward their absorption; and clinical

experience has shown that the visible local lesions do not respond to any other possible effect of x-ray exposure upon the tissues. Moreover, any tendency toward the relief of the pain attending the local manifestations of the disease is exceptional.

Chronic Arthritis.—Radiation has been extensively employed in the past in the treatment of the different types of chronic non-tuberculous arthritis. While it has afforded more or less temporary relief from pain or discomfort, and the functional use of the affected joints has been restored to a certain extent in many instances, complete and especially permanent symptomatic cures have been exceptional. Applications of the high-frequency or the static currents have yielded far better results, on the whole, and these agents have largely superseded the x-ray in the local treatment of such joint conditions.

Diseases of the Nervous System.—*Neuralgia and Neuritis.*—Practically the only value of x-ray therapy in connection with disorders of the nervous system is in its use for the relief of pain. Its experimental use in neuralgia and neuritis was begun comparatively early in the history of Roentgen therapy, having been suggested by the frequent observance of the analgesic effect of the x-ray exposures in the treatment of malignant growths. The early partial or complete relief of pain that is afforded in the majority of instances has become a prominent feature of the palliative treatment of malignant growths, and it would certainly seem reasonable to expect radiation to exert a similar analgesic effect upon nerve pains of other origins. The pain in malignant growths is less likely to be relieved the deeper seated the nerves involved, especially when due to a considerable amount of pressure upon large nerve-trunks, in which case the pressure must be lessened before pain can be relieved, as a rule. The use of radiation in neuralgia is suggested also by curious effects that have often been observed by radiographers following radiographic exposures. It has not infrequently been noted that a severe pain in the back in a case examined for possible renal calculus or some other condition, or neuralgic pains in the face or head when these parts are examined, for the purpose usually of determining the cause of this very symptom, have been temporarily or even permanently relieved as a result of the examination.

As to the real value of radiation in neuralgic pains and those due to neuritis, it may be stated that it is successful in practically only a small percentage of cases, but is decidedly beneficial, however, in a definite proportion, and is well worth trying in almost any obstinate case in which simpler or ordinarily successful measures fail. When a definite and active cause is apparent, as in many cases of neuritis, x-ray treatment is not so likely to succeed unless it is able to exert some influence toward the removal of that cause, as the pressure of scar tissue, for example. It is perhaps more often successful in the cases in which no definite cause for the pain is apparent, or, in other words, cases of neuralgia rather than of neuritis. Successful results have frequently been obtained in cases of neuritis, but more especially neuralgia, of

many of the nerves, particularly the trifacial and its divisions and their branches, the facial, the brachial plexus, and the intercostals. In a few instances cases of migraine of long standing have been considerably improved and even apparently cured by a few x-ray applications.

The exact action of radiation upon nerve tissue in the production of these results is not definitely known, although several explanations have been offered. It is believed by some that x-rays exert some peculiar direct anesthetic effect in the nerve tissues exposed, while the reason assigned by others is a stimulation of impaired nutrition or correction of faulty metabolism, in the belief that it is only cases in which these processes are at fault that can be favorably influenced by x-ray treatment. The effects have been ascribed also to the influence of the electric field in the proximity of the tube rather than to the x-rays themselves, but it is now generally believed that the former has little or nothing to do with the results obtained.

Cases that do respond to radiation vary considerably in respect to the amount of treatment they require. In some instances a single and comparatively short application has sufficed to afford permanent relief, although this is unusual. In most cases benefited, the first few exposures, or even the first one, afford some relief and suggest a favorable result, and, as a rule, anywhere from 4 to 10 or a dozen applications are required for a satisfactory result, whether it be temporary or permanent. The cause, when known, has, of course, an important bearing upon the length of treatment needed. In severe neuralgias there is seldom much use of prolonging it much beyond the limits just mentioned if the cases do not respond after such a number of applications, unless there is good reason to expect that further treatment will do good. As a rule, the applications should be short and the dosage of each usually represents an x-ray volume not far from that which would be necessary for a radiographic exposure. The entire dosage volume needed does not exceed that which would be productive of a greater reaction than a very mild stimulation.

The application of high-frequency or sometimes static electric currents is more efficient than radiation in perhaps a much larger percentage of cases of neuralgia and neuritis, but there are many instances in which x-ray treatment alone will prove beneficial.

Locomotor Ataxia.—As radiation exerts no influence upon the lesions, it can have no value whatever in connection with the treatment of this disease, except possibly in an attempt to relieve pain. Although it has, in rare instances, perhaps, afforded some relief, the effect has been but temporary. High-frequency applications are far more likely to be beneficial, though even they do little if any good, as a rule.

Epilepsy.—In a few instances attending x-ray examinations of the heads of epileptics, it has been noted that the attacks have been less frequent or even ceased for a short period afterward. This having occurred a sufficient number of times to prove that it was not altogether a coincidence, it suggested a possible therapeutic value in

radiation in the treatment of epilepsy, especially the idiopathic variety. Experimental work along this line has failed to develop any such practical use for x-ray therapy in this condition, however. Although in many instances attacks have become less frequent or even ceased for a time under experimental therapeutic applications, the effect has not been lasting, and occasionally the attempt has resulted in an increased frequency of the attacks.

MISCELLANEOUS THERAPEUTIC MEASURES

By George P. Müller, M.D.

BLOOD-LETTING OR VENESECTION

At the present time venesection is employed much less frequently than in the past, but it is often of advantage, and, perhaps, is a method of treatment which should be more often employed. Some twenty or thirty years ago the reaction against bleeding had become so acute that the practice was almost unknown, but of recent years it is more in favor, and seems to have certain few but positive indications. The reduction of the blood-pressure by the withdrawal of a certain amount of fluid is not the only advantage it possesses; the circulation is improved by the thinning of the blood, the composition of the blood is improved by the regeneration of the cells, and the urinary secretion is increased. Wilks has graphically described the patient whose condition calls for bleeding as follows: "You see your patient sitting up in bed, the face, tongue, and lips blue or purple, and the jugular veins starting out of the neck and often visibly pulsating, the heart beating quickly, and perhaps a tricuspid bruit, indicating the gorged right heart and obstructed lungs; the veins in the body are full to bursting."

Phlebotomy is indicated: (1) In certain cardiovascular affections where valvular disease has resulted in failure of compensation, extreme dyspnea, cyanosis, rapid, feeble pulse, distended veins, and a tumultuous heart action being present. If the usual remedies fail, the withdrawal of 15 to 20 ounces of blood relieves the distention of the right heart and better enables the circulation to regain its equilibrium; it should be noted that a small pulse is not a contraindication to venesection, as the blood is dammed up in the venous system. (2) In acute pulmonary edema. (3) In croupous pneumonia when the right heart is dilated. (4) In uremia, because of the high tension of the circulation and the accumulation of toxins in the edematous brain. (5) In eclampsia, unless delivery is accompanied by loss of blood; Kottmann objects to the use of physiologic salt solution in uremia after bleeding as it increases the brain edema. (6) In carbon monoxid poisoning. (7) In obstinate chlorosis, in order to stimulate the sluggish circulation. (8) In sunstroke, when the symptoms are those of intense asphyxia. (9) In cerebral hemorrhage (apoplexy). It should be remembered, however, that the rising blood-pressure with a pulse of high tension is due to the effort of the vasomotor mechanism to force blood through the brain. If the clot is accessible, it should be removed, the relief of intracranial pressure thereby promptly reducing the vascular tension.

Certain cases of arteriosclerosis, emphysema, pulmonary engorge-

ments, etc., with symptoms like those described by Wilks, are often distinctly benefited by the letting of 10 or 15 ounces of blood. In the recent literature bleeding is recommended for a great variety of conditions, but unless the indication is clear, the procedure may do more harm than good.

Phlebotomy is performed as follows: The patient should be sitting up in bed, so that warning of approaching syncope may be given. The arm, held extended and abducted, is cleansed at the elbow as in any surgical operation, and a bandage firmly bound round the middle of the arm to compress the venous return, but not the arterial flow. It is of some advantage to allow the arm to hang down for a few minutes before applying the bandage, and the hand should grasp some object, such as a roller bandage, to aid the distention of the veins. The most prominent vein should be chosen, usually the median basilic, the arm grasped and steadied by pressure of the left thumb just distal to the point of the intended incision. A bistoury with its back to the arm is then thrust through the skin and vein, and brought obliquely upward and outward, thus cutting the vein about two-thirds through. The arm is then turned round over a basin or measuring glass and the thumb removed. The desired amount of blood is allowed to escape or until approaching syncope is indicated, when the constriction is removed, a sterile gauze pad placed over the little incision, and a figure-of-eight bandage applied. Unless the operator is skilled in performing phlebotomy, it is better to expose the vein by a longitudinal incision one centimeter long, isolate it from the underlying structures, and then divide, instead of following the technic just described. The brachial artery lies beneath the median basilic vein, and may be wounded, causing troublesome hemorrhage or an arteriovenous aneurysm. If the internal cutaneous vein is cut, neuralgia may result. In stout people it is always safer to thoroughly expose the vein, and if no available vessels can be obtained at the elbow, the internal saphenous may be used about two inches from the femoral vein. If bleeding cannot be controlled by the pressure of the gauze pad, the wound may be enlarged and the ends of the vein ligated. Some physicians extract the blood by the use of a large antitoxin syringe, the vein being punctured through the skin in the same manner as in the taking of blood for bacteriologic investigation. The needle attached to the syringe is plunged obliquely through the skin and alongside of the vein; the point is then turned to the vein, which is then picked up by the needle as it is thrust into it. The syringe should slip on and off the needle and not have a screw-joint.

LEECHING

The use of leeches to withdraw blood from an inflamed or contused area is still employed in certain instances, although their use is objectionable to the patient, and sometimes productive of infection. They are usually applied over areas where cupping cannot be employed, such as the mastoid, about joints, beneath the eyes, etc.

The leech should not be placed directly over the inflamed part, but contiguous to it; nor should it be applied to parts which are very loose in texture, such as the scrotum or eyelids, otherwise extensive ecchymosis will follow. They should not be applied over an artery or vein. When used for an inflamed eye, they are placed near the inner canthus; when for an orchitis, they should be applied over the spermatic cord, below the external ring.

Method of Application.—The area to be leeched must be carefully cleansed. The leeches should be removed from the water in which they are kept an hour or two before wanted, and placed in a test-tube or medicine-glass. The latter is placed over the part and the leech shaken down by tapping the glass, or the tube may be partly filled with water and, after inverting on the skin, the water is allowed to escape, thus causing the leech to adhere to the part. A drop of milk, syrup, or blood may be used to encourage the leech to take hold. Several leeches should be at hand, as one sometimes fails to attach itself, and a single leech can withdraw but a dram or two of blood, after which it usually drops off. A little salt sprinkled on the leech will discourage prolonged holding. After the leech has taken hold, a piece of cotton should be slipped between it and the skin, because the movements of the leech are productive of unpleasant sensations.

The resulting wound is triangular in shape, and sometimes bleeds sharply, which further aids the depletion. This bleeding may be encouraged by applying warm, moist compresses over the part. If the hemorrhage proves troublesome, it may be checked by means of pressure with gauze pads and a bandage or by the application of a styptic. An artificial leech can be obtained from instrument dealers.

EXTERNAL APPLICATIONS

External heat, whether applied generally or locally, is used to give additional warmth to the body, to act as a diaphoretic, or as an agent in the treatment of inflammation when the reaction is insufficient (inadequate)—*i. e.*, when it is desirable to increase the hyperemia, encourage the exudate, and lessen pain. It is particularly useful in painful spasmodic affections or colics. It should not be used in cutaneous inflammations. Heat is usually applied in the dry form by means of hot-air baths, hot-water bags or bottles, or, in the moist form, by means of fomentations, poultices, or warm douches.

Hot-water bags or bottles are very frequently used to apply dry heat, and it suffices to state that they should be covered with flannel or a layer of blanket and should not leak, and should not be more than half full of the hot water. As most patients who require the application of heat have a lowered vitality, it is an easy matter for them to sustain a burn, which may prove troublesome to heal and injurious to the reputation of the practitioner; great care should, therefore, be taken to avoid such burns.

A *fomentation* or *stupe* is made of a piece of flannel, old blanket, or, what is much more elegant, of sheets of lamb's wool incased in a

gauze cover, over which is put a layer of oiled silk. Several layers of the material should be placed in boiling water, lifted in a stupe-wringer, wrung dry, applied to the patient's skin, and covered with cotton-wool, oiled muslin, or paper. The fomentation must be applied every ten or fifteen minutes, and may be made antiseptic by the use of corrosive sublimate (1 : 1000) or carbolic acid (1 : 40). In no case should they be left on until cold and clammy. The stupe-wringer is made of a piece of ticking 18 inches long and 15 inches wide, with a hem at each end, through which a stick is introduced. This rests in the bottom of the boiling water and holds the flannel as in a hammock; the sticks are then twisted in opposite directions, the flannel wrung out tightly, and carried in the wringer to the bed. Small hot compresses for the eye or ear may be wrung out tightly in a lemon-squeezer.

Poultices are commonly used to encourage the softening of the exudate in an infected area, such as a furuncle or carbuncle. They are dirty, sticky, and often septic, and their use should be discouraged, as in most cases where moist heat is desired the antiseptic fomentation is quite satisfactory. Infected areas should be opened at an early period, and not poulticed until a soft pus-sac has formed. Many substances have been employed for poultices, of which the old-fashioned bread or flaxseed and the modern glycerinated earthy substances are the best known. There is but little difference between the action of flaxseed and cataplasma kaolini, the former being the better retainer of heat. Neither material is antiseptic nor absorbent, and consequently the purulent material is held in close contact with the skin, reinfecting hair-follicles and tending to produce a second "crop of boils." If, however, the flaxseed poultice must be used, a moist sterile dressing should be placed between the wound and the poultice.

To make flaxseed poultices the meal should be stirred slowly and evenly into boiling water until thick enough to make a light, smooth paste that just drops away from the spoon. It should then be beaten well to make it lighter by introducing air. It is then spread in a layer one-half inch thick on a piece of muslin, leaving a margin of one inch to be turned over. The flaxseed surface should be covered with a layer of thin gauze which has been impregnated with vaselin, the edges turned over, and the poultice rolled in a towel and carried to the patient. After being applied, it should be covered closely with a layer of cotton, wool, or oiled silk, to prevent the escape of the heat and moisture. It should be changed as often as is necessary to retain the effect of continuous heat.

Charcoal poultices are made by adding one part of powdered charcoal to two parts of the flaxseed, and with a dash of chlorinated soda. They are sometimes used in gangrenous conditions, to relieve the pain and destroy the odor, but is a very untidy dressing and much inferior to wet fomentations of permanganate of potassium.

A *starch poultice* is sometimes used in irritating skin diseases, and is made in a similar manner as the flaxseed, substituting starch for the flaxseed.

A *spice poultice* may be indicated when mild counterirritation is desired, and is made by placing equal parts of cloves, cayenne pepper, ginger, and cinnamon in a bag, which is submerged for a few moments in hot alcohol or vinegar, wrung out, and applied. A paste may be made of the spices, hot alcohol, and flour, and applied on gauze or muslin. The cloves and pepper are the irritating substances in this poultice.

Cold Applications.—Cold may be applied by means of the cold bath or by compresses, packs, sponging, coils, or ice.

The ice-bag is the most effectual way to apply cold continuously, and is made in all sizes and shapes. It is particularly valuable in inflammatory affections of the throat, cranium, chest, and abdomen; to control oozing from a wound; to quiet the heart action in tachycardia; to reduce the congestion in a thyroid gland, as in exophthalmic goiter; and to relieve the pain of appendicitis while awaiting surgical interference.

The bag should never be more than half filled, should not be placed directly on the skin, and the cold may be intensified by adding salt to the ice. It should not be used in purpuric affections nor when the vitality of the tissues is low. The other uses of cold applications are discussed in the chapter on Hydrotherapy.

Soothing Applications.—Lead-water and laudanum (lotio plumbi et opii, N. F.) has been used for years as a lotion in the treatment of painful inflammations, especially those of a non-infectious character, such as sprains, dislocations, fractures, etc. It probably owes any virtues it may possess to the alcohol present. The remedy is applied by saturating a piece of lint or gauze with the lotion, and covering with some impermeable covering. A saturated solution of magnesium sulphate is more efficient and more cleanly.

COUNTERIRRITATION

Counterirritants act either by producing changes in the blood-supply of the skin, and secondarily of the deeper structures, or by a reflex nervous action, trophic or vasomotor, of the tissues.

The simplest form of counterirritation is friction, especially when aided by some mild irritant, such as chloroform liniment; mustard, in the form of plasters or poultices, turpentine stupes, iodin, and blisters are also of value as counterirritants.

Mustard.—A poultice consisting of one part of ground mustard mixed with six parts of flour or ground flaxseed and the white of an egg is rubbed thoroughly with cold water into a paste and spread between two layers of muslin or linen of the size required. The poultice is applied for ten to twenty minutes, and removed when the stinging sensation becomes acute and the skin well reddened. After removal, the skin should be covered with cold-cream or vaselin.

Turpentine.—Stupes are prepared by stirring one-half ounce of turpentine in a pint of boiling water until emulsified. The stupe is then wrung out (p. 674) and applied to the part, being covered with

gauze or cotton-wool and oiled paper or muslin. Another method is to mix one part of turpentine with seven of olive oil and apply to the part; over this the hot fomentation (p. 673) is placed.

Iodin.—Tincture of iodin, when painted on the skin, produces a hyperemia of the skin and stimulates the terminal nerve filaments. Two coats should be applied, unless the skin is sensitive.

Blisters.—Cantharides is used either in the form of a plaster (emplastrum vesicatorium) or in solution in collodion (collodium cantharidatum, U. S.). They are valuable in the treatment of unresolved pneumonia, pulmonary tuberculosis, chronic arthritis, and in certain digestive disturbances associated with obstinate nausea. They should not be used over an effusion, as the aspirating needle is far more efficacious. The plaster should not exceed one inch in size, and the skin should be carefully cleansed before application in order to avoid infection. It remains in place for from four to eight hours, according to the effect desired, and is removed by carefully detaching and elevating the sides; the blister should then be punctured, the serum drained, and the surface protected with a dressing of sterile gauze. If, at the end of eight hours, vesication has not occurred, a hot fomentation will produce the exudation. The skin should never be clipped away. The blistering may be repeated continually (flying blisters).

CUPPING

The application of cups is indicated in pneumonia and pleurisy to relieve pain and congestion, in nephritis to promote the flow of urine, and in lumbago to relieve pain. They probably act by stimulating the circulation of the part by a reflex nervous influence upon the sympathetic nerves.

Dry cups and wet cups are used, the former being more powerful and more convenient.

Method.—*Dry Cups.*—Special cups are sold in the instrument shops, consisting of a glass bulb with a globular hollow tube of rubber (Fig. 219). The rubber bulb is emptied of air, the edge of the glass greased with vaselin, and, after applying pressure on the bulb relieved. It is not necessary to have such cups, however, as the method can be performed just as easily with a tumbler, wine-glass, medicine glass, etc., the edge of which has been greased. A bit of blotting-paper wet with alcohol should be placed in the bottom of the glass, lighted, and after a brief period the glass is inverted and placed upon the skin. A second method is to wet a cotton swab with alcohol, and quickly pass it lighted to the bottom of the glass. The latter and the air contained in it is heated in a few seconds, whereupon the cup is applied to the skin. A third method is to pour a few drops of alcohol into the glass and manipulate it around the bottom and sides of the lower half,

Fig. 219.—Rubber bulb cupper.

after which it is lighted with a match and the glass quickly turned on to the skin. Of course, these various methods are possible by reason of the partial vacuum produced as the air in the glass cools, the tissues rising to take its place. To avoid burning of the skin it is essential not to get the edge of the glass hot, or of allowing any of the alcohol to drip while the glass is being applied, otherwise serious burns may result; in all cases the edge of the glass should be well greased. To remove the glass the skin should be pressed down with the thumb or finger, allowing the air to enter the glass, which can then be taken off.

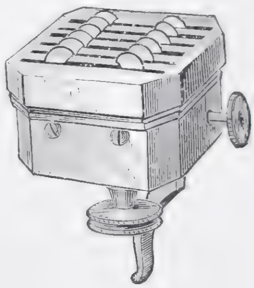

Fig. 220.—Scarificator.

Wet Cups.—In the use of these implements a wound is produced and the skin should, therefore, be thoroughly cleansed or rendered aseptic before they are applied. The skin should then be scarified by a number of shallow incisions made with a scalpel or with a scarificator (Fig. 220). The cup is then applied, and a dram or more of blood withdrawn.

BIER'S PASSIVE HYPEREMIA

As a result of injury—mechanical, thermal, bacterial—the tissues react locally and exhibit certain phenomena, which always have a distinctive tendency to produce repair of the damaged tissue. The principal phenomenon of inflammation, at least in its early stages, is hyperemia. The increased amount of blood supplied to the injured or infected part is of great importance in getting rid of the irritant and of stimulating repair of the tissues. In 1892 Bier began to treat infected tissues, especially joints, by deliberately producing hyperemia in an effort to assist the natural processes. The success of this method of treatment is believed to depend upon the coincident working of bacteriolysis and phagocytosis. By increasing the pressure in the capillaries, the focus of infection is flooded by a lymph having antitryptic and opsonic powers, arresting the further destructive action of ferments, and inhibiting bacterial growth. When the bandage is removed, the circulation reëstablishes itself, the lymph moves out of the affected part, liberating more or less endotoxin, which exerts an influence upon the bactericidal power of the blood, generally by the stimulation of antitoxins, alexins, opsonins, etc. If any of the factors of this relation are altered, the results of the method must vary, thus accounting for the conflicting results obtained by different operators in acute infections. The endotoxins liberated during the interval or pause in the treatment may give rise to serious symptoms in severe cases. This is evident clinically by a rise in temperature and sometimes by chills. Lexer believes that this injurious action may be avoided in severe acute cases by large and early incisions,

instead of the small ones recommended by Bier. In general it may be stated that the indications for Bier's hyperemia are the same as for the bactericidal serums; hyperemia is most successful when complete bacteriolysis is present and the number of bacteria small.

Method of Application.—Passive hyperemia may be induced by means of an elastic bandage applied to an extremity, by suction cups similar to the ordinary dry cup, and by means of vacuum chambers into which part of the limb is introduced. The cup is the most generally useful of these, requiring but little intelligence or skill in its use, and consequently is rarely productive of harm.

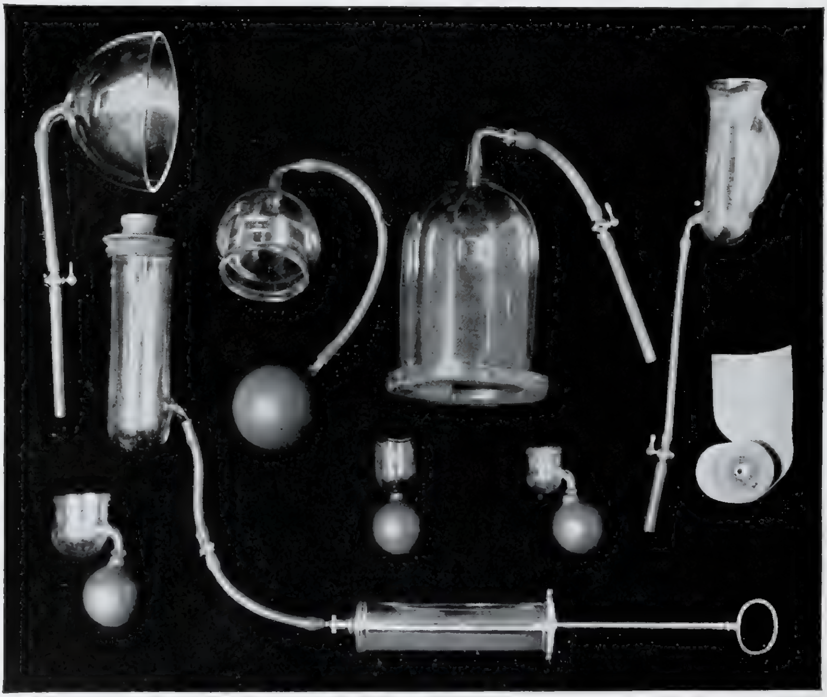

Fig. 221.—Suction cups. Varieties of suction cups designed for various anatomic regions; suction pump; rubber bandage (Crandon).

The cups devised by Klapp are made to fit any part of the body, being of various shapes and curves. The cup consists of a glass bowl with a heavy and usually curved rim and bulb attachment to exhaust air. Furuncles, carbuncles, small abscesses, sinuses, and fistulæ are the conditions for which the suction cups are most useful.

There are two points to be considered before using this method of treatment: First, the diameter of the cup must exceed the area of infiltration, and, second, the amount of pressure must be regulated, because if the vacuum is too little, nothing is attained, and if too great, pain and white edema are produced.

The rim of the cup selected is greased with vaselin and the bulb compressed in the right hand; the cup is then applied over the furuncle or sinus and the pressure slowly released. The skin and underlying tissues are sucked into the cup, hyperemia appears as a red or bluish coloration, while pus, serum, and blood ooze from the wound. At the end of five minutes the cup should be removed, the exudate wiped away, and the part allowed to remain at rest for about three minutes, whereupon the cup is again applied. This intermittent treatment is continued for forty or forty-five minutes, and a simple dressing applied.

The treatment should be continued daily and the time of application gradually decreased as the discharge becomes thinner and the granulations red and firm. All scabs or crusts should be removed from over sinuses before beginning treatment, but squeezing, probing, or cureting should not be done. It must be distinctly understood that the cups produce merely a hyperemia, which carries into the infected tissues fluids which tend to neutralize the infection; if pus has already formed, it must be evacuated by an incision, after which the cup is applied. Cold abscesses may safely be opened if due care is exercised in their protection, but should not be cureted, probed, or injected with iodoform emulsion; nor is immobilization necessary. Very large suction glasses are made for the treatment of puerperal mastitis, and are provided with a suction pump and stop-cock arrangement.

Fig. 222.—Passive hyperemia. The rubber bandage in place; note the distention of the veins and the cyanosis (Crandon).

The elastic bandage, as used by Bier, is made of soft rubber, $2\frac{1}{2}$ inches wide, and sufficiently long to be wrapped six or eight times around the limb, and then fastened by safety-pins, tapes, etc. The bandage should be wound as far above the affected area as possible, and always should be applied to the thigh or arm if the leg or forearm is affected. After powdering the skin with talcum powder, the bandage should be wound about the limb, each time overlapping slightly, and sufficiently tight to hinder definitely the venous return, but not sufficiently to diminish the arterial flow, the latter point being determined by feeling the pulse below the obstruction. In a few minutes the limb becomes swollen and of a deep red or purple color up to the bandage, the skin feeling warm to the touch. The resulting

edema is at times alarming, but if the pulse can be felt below the bandage, the limb is warm, and no great pain is present, there is no need to release the pressure. The edema, however, should not be allowed to persist, but between applications absorption should be promoted by elevating the limb and by massage. The bandage remains *in situ* for from one to twenty-two hours, depending upon the condition for which the treatment is instituted, but its position should be changed after about ten hours in one place. When applied for any length of time, the skin must be protected by a soft flannel bandage beneath the rubber. The constriction should never be placed upon an affected portion of the limb.

The application of the Bier bandage requires the utmost care and watchfulness, especially during the first few applications. The physician himself should attend to the treatment, as the method is capable, in acute cases, of doing more harm if improperly applied than it does good if correctly done. Excessive pain, paresthesia, a cold, white, edematous limb, and obstruction of the pulse below the constricting band must be rigidly avoided. All dressings and bandages must be removed before applying the bandage, the wound being protected by a loosely applied sterile towel; severe cases should be treated in bed; all pus should be evacuated by as many incisions as may be necessary, but they do not need to be as long as when passive hyperemia is not used, nor should the wound be packed or curetted; free incisions are required only when the circulation of the part is seriously impaired.

SPINAL PUNCTURE

The spinal canal may be punctured to obtain the cerebrospinal fluid for diagnostic purposes, to inject an anesthetic or other drug, or to drain the fluid to relieve pressure in the cerebrospinal tract.

The physical characteristics of the fluid can be determined—whether containing pus in suspected meningitis or blood in subdural hemorrhage. The degree of intraspinal pressure may be approximately gaged by the force of the jet, or it may be measured by attaching a manometer to the needle. The chemical characteristics, bacterial content, and microscopic character can also be determined.

The injection of various drugs, such as cocain, tropacocain, alypin, novocain, eucain, etc., into the spinal canal for the purpose of producing analgesia has obtained a distinct revival of interest in recent years. At the present time tropacocain and stovain are most often used, the latter, in combination with strychnin, being the one widely popularized by Jonnesco, of Bucharest. The doses of these different drugs vary, but stovain and tropacocain are generally given in amounts varying from 1 to 10 centigrams, depending upon the age and general condition of the patient. About 6 centigrams is the average dose for an adult, and it should be made up with 10 per cent. of alcohol and carefully sterilized.

Magnesium sulphate, being a nerve depressant, has been used with some success in combating the convulsions of tetanus. One cubic

centimeter of a 25 per cent. solution in water to each 25 pounds of the patient's body-weight is injected into the spinal canal. The solution must be carefully sterilized, and if respiratory embarrassment occurs, the canal must be repunctured and the salt drained out. Tetanus antitoxin, about 1500 to 2500 units, may also be injected in tetanus into the spinal cord.

Technic.—The cord ends at the lower border of the first lumbar vertebra, and any intervertebral space below that point avoids injury to the cord, but to those of experience such an accident is unusual, and injections for anesthetic purposes have been made even as high as the cervical region. The needle should be of iridium platinum, about 8 centimeters long, and with a short bevel point. It should be fitted with a stilet, exactly fitting the bevel end of the needle. The needle used by most physicians for this purpose is entirely too sharp, and has too great a bevel and diameter. If it is intended to inject fluid into the canal, the syringe used should be of glass, of the Luer type, and have a capacity of 2 c.c. The patient's back should be prepared as carefully as for any surgical operation.

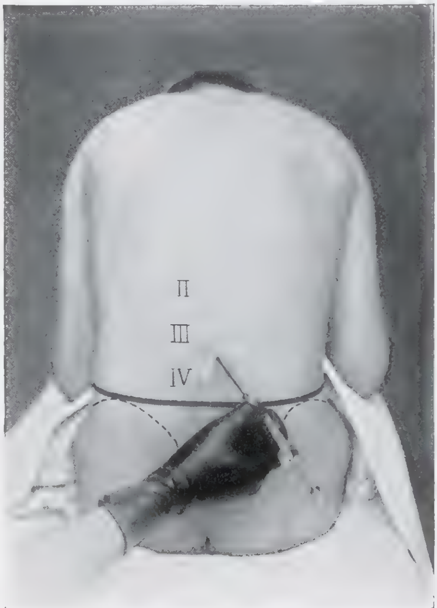

Fig. 223.—Showing the flexed posture of the patient and the point for making the lumbar puncture, one centimeter to the side of the median line, and between the third and fourth lumbar spines (Keen's Surgery).

The patient should sit upright upon the edge of the bed or table and, leaning forward, support himself by hands upon knees so as to round the back and increase the transverse width of the intervertebral spaces (scorcher's position). When the patient cannot sit up, the Sims position may be used. For diagnostic purposes the operator should select the interspace between the third and fourth lumbar spines in which to make the puncture, and this may be located by placing a sterile towel across the back, with its upper edge touching the iliac crests. This line crosses the spine either upon the fourth lumbar interspace or the fourth lumbar spine. If it is desirous to use the spinal puncture for purposes of anesthesia, the fluid is best injected into the interspace between the twelfth dorsal and first lumbar spines, unless the operation is upon the lower extremities, in which case the former point may be used. For operations on the head, neck, upper limbs, and thorax Jonnesco punctures between the first and second

dorsal vertebræ, but this procedure is open to grave dangers to respiration.

The ball of the thumb should be placed against the spinous process above the selected interspace, and the area at the level of the nail frozen with ethyl chlorid. Some operators make a scalpel puncture through the entire thickness of the skin, but others do not regard this as necessary. As soon as the skin is frozen the needle is introduced at right angles to the skin, and about 2 mm. from the median line. After traversing the skin the needle easily journeys through the tissues until the ligamentum subflava is felt, which often offers dense resistance. At this point the stilet should be withdrawn and the needle cautiously pushed forward until the point enters the spinal canal. This will be denoted either by the snap of the dura as it is punctured or by the escape of cerebrospinal fluid in drops or in jets from the needle.

As soon as the escape of cerebrospinal fluid shows that the arachnoid space has been entered, the thumb should be placed over the end of the needle until the collecting tube or syringe can be attached. The loss of too much fluid may cause faintness, pallor of the face, sweating, etc., and sometimes vomiting and headache afterward.

If the purpose of the puncture is for anesthesia, the syringe containing the solution should be attached to the needle and the piston gently drawn until an equal quantity of fluid escapes into the syringe and mixes with the anesthetic. The mixture is then rather rapidly injected, and the needle with the attached syringe quickly withdrawn. If the purpose of the puncture is to relieve excessive tension, the cerebrospinal fluid should be evacuated until 10 c. c. have been withdrawn, or until the fluid begins to drip from the needle. If a manometer is available, and one can be easily manufactured with a U tube and some rubber tubing, the fluid should be withdrawn until the pressure approaches the normal. After the needle is withdrawn no dressing is required for the puncture except some collodion and cotton.

The most common causes for failure in the spinal puncture are: First, improper posture of the patient; second, inclining the needle upward or downward or too far to one side of the median line, instead of at right angles to the vertical axis of the spine; in this case the needle strikes the laminæ; third, the improper needle, that is, one with too long a point or without a stilet; in the latter case the lumen of the needle becomes occluded with tissue or blood-clot; fourth, anatomic peculiarities, such as where laminæ are very close together. In this case a new interspace should be selected, or the patient placed on the side over a pillow and the injection made over a point about one-half inch from the median line.

Occasionally the fluid does not run out freely, though the needle is in place; in such a case the patient should be directed to cough vigorously, or the stilet should be reintroduced and suddenly withdrawn, thus establishing suction.

ACUPUNCTURE

The intense pain of acute and muscular rheumatism of the lumbar muscles (lumbago) may often be immediately relieved by thrusting needles into these muscles at the seat of pain. The needles should be thin, about three or four inches long, and introduced with aseptic precautions; they should remain *in situ* for three or four minutes. Ordinary hat-pins may be used.

PARACENTESIS

Paracentesis of the Abdominal Cavity.—This operation may have to be done for marked distention of the abdomen, with fluid as in the atrophic form of cirrhosis of the liver. The differential diagnosis must be carefully made, however, and the practitioner be sure that he is not plunging the trocar into an abdomen distended by gas, and not by fluid. Such an occurrence would probably mean the penetration of a loop of intestine, with escape of its contents and a rapidly spreading peritonitis. Dulness to percussion and a wave of fluctuation must be obtained, and the latter must be carefully distinguished from the pseudofluctuation wave which is often elicited in distention of the intestines with fluid in them. An ovarian or other intra-abdominal cyst should also be carefully excluded, and careful questioning directed to determine if the bladder is empty or distended.

Method.—The pubes should be shaved, the bladder evacuated, and the skin of the lower abdomen carefully sterilized—a small scalpel, trocar, cannula, and rubber tubing are required, which should also be sterilized.

The patient should be placed on the side, and the puncture made in the semilunar line, which is readily located at the outer border of the rectus muscle. This point is avascular, and there is the further advantage of having the patient in the recumbent position if syncope should threaten to develop.

Many physicians, however, prefer to have the patient in a sitting position on the edge of the bed or table, with a suitable back-rest, or on a chair, and a point selected in the middle line, midway between the pubes and the umbilicus.

The skin is rendered insensitive by freezing with an ethyl chlorid spray, a small puncture made in the skin with the knife, and the cannula, in which is the trocar, thrust into the abdominal cavity. The trocar is withdrawn, and the fluid is drained into a suitable vessel through the rubber tubing. Many quarts are often removed, and sufficient vessels should be provided. A broad bandage is often passed around the abdomen and tightened from time to time, to maintain the intra-abdominal pressure. Toward the end the flow often stops suddenly, due to the plugging of its opening by intestines or omentum, but by gently turning in a different direction, the flow may be reëstablished, although it is generally impossible to remove all the ascitic fluid. When the fluid has been drained off, the

cannula is withdrawn and the opening closed with a small piece of gauze and collodion.

The pulse should be carefully watched during the operation, as the relief of pressure allows the abdominal veins to fill up, and stimulants may be required. There is practically no danger of wounding the intestines if the diagnosis has been correct, as they are floated up out of harm's way. Infection rarely occurs, owing to the thickened condition of the peritoneum.

Aspiration of the Chest.—The pleural cavity is frequently explored

Fig. 224.—The method of making the puncture for aspiration of the chest (Eisendrath).

for the purpose of ascertaining the existence of fluid in a case of pleurisy, and for the purpose of removing such fluids if it is demonstrated. Early aspiration of the pleural effusion of moderate or severe grade should always be done, as the risk is almost *nil* and benefit to the patient great.

Method.—The site for the exploration should be the place where the physical signs suggest the presence of fluid unless the effusion is present in considerable quantities, in which case the spot selected should be either in the seventh intercostal space in the midaxillary line (Fig. 224), or in the eighth space, at the outer angle of the scapula. The

surface of the skin should be carefully cleansed with soap, alcohol, and the spot selected touched with tincture of iodin, the arm of the patient being brought forward and the hand placed on the opposite shoulder, so as to increase the width of the intercostal spaces. The skin is then steadied by the forefinger and thumb of the left hand, and the exploratory needle attached to the syringe is thrust in sharply, just above the upper border of the rib. On withdrawing the piston of the syringe the fluid will flow into the barrel, and may be preserved therein for subsequent examination, both as to its cytologic and bacteriologic properties. The needle is then rapidly withdrawn, and the puncture covered with a small piece of gauze and collodion.

The needle employed for this purpose should be fairly stout, about three inches long, and quite sharp. It is better to have a syringe connected with the needle by a push joint than a screw-joint, owing to the greater ease of manipulation. If no fluid is obtained the needle should be withdrawn and reintroduced at several other places suggested by the physical signs, but should not be thrust in various directions after having been introduced, owing to the fear of injuring the lung. If the patient is timid, or feels pain acutely, the skin should first be frozen with an ethyl chlorid spray or some cocain injected into the skin. If the needle is not perfectly sharp, and in some persons with particularly tough skin, it may be necessary to make a small puncture in the skin with a scalpel before the needle can be introduced.

If fluid is detected and its aspiration decided upon, it is essential to have an aspirating outfit, bottle, and exhaust pump, with rubber tubes and valve connections. If possible, the bottle and connections should be sterilized with the needle; the air is then exhausted from the bottle by the pump and stop-cock closed, and after thrusting the needle into the fluid collection, the connection is made, the stop-cock opened, and the fluid rapidly runs into the bottle to supply the vacuum. If the collection is a small one, it is best to tap close to the exploratory puncture, but otherwise the seventh intercostal space in the mid-axillary line should be selected. The fluid should be withdrawn slowly, and be temporarily stopped if spasmodic coughing occurs, or stopped altogether if the fluid becomes blood stained. It is usually necessary to use cocain or eucain to anesthetize the skin, and to make a small puncture with the knife before introducing the needle.

Pain, cough, and giddiness are frequently complained of after a certain amount of fluid has been withdrawn, but usually subside in a short time. Subcutaneous emphysema may develop from the point of puncture, but does not produce pneumothorax unless the needle has injured the lung. Infection, with subsequent empyema, readily occurs if aseptic precautions are not observed, and if detected, should be promptly evacuated by an incision, resection of a rib, and tube drainage.

Paracentesis of the Pericardium.—The presence of symptoms indicating great interference with the circulatory function and physical

signs of an effusion of considerable extent will be the indications for aspirating the pericardium in a case of pericarditis with effusion.

Method.—A point in the fifth or sixth interspace, one inch from the left border of the sternum, is the place of election for making the tapping. Puncture in the fifth interspace on the right side is advised by some as minimizing the danger to the heart. Deguy recommends incising over the xiphoid, resecting the latter, and after detaching the diaphragm, the pericardium can be drawn down and forward and incised. The internal mammary artery descends vertically about one-half inch from the edge of the sternum, and ordinarily the pleura is also beneath this point, but when the pericardium is distended, the

Fig. 225.—Method of performing paracentesis of the pericardium (Eisendrath).

pleura is pushed away, and there is practically no danger of penetrating it. The skin should be carefully cleansed with soap and water, alcohol, and lightly brushed with tincture of iodin, and a needle similar to the one described under pleural effusion thrust upward and backward into the pericardium. Repeated tapping may be needed, but if the effusion is purulent, a more radical operation is indicated.

Tapping a Hydrocele Sac.—The simple tapping of a hydrocele is rarely curative, as the pathologic condition of the serous surfaces is unchanged, and the effusion will return. A certain number of recoveries will occur from the injections of some irritant, such as carbolic acid or iodin, which, by producing adhesions between the layers of the sac, may obliterate it. As a rule, however, a hydrocele should

be treated by a surgical operation with inversion of the sac. In certain cases operation may be contraindicated by reason of the age of the patient or disease of the lungs, kidneys, etc., or the patient may refuse operation, in which event tapping would have to be performed.

Method.—The patient should be sitting in a chair or lying on a table, and the scrotum carefully cleansed with soap and water and bichlorid of mercury solution (1 : 1000); alcohol generally causes considerable smarting, and should be avoided. The exact position of the testicle must always be determined, and the scrotum grasped from

Fig. 226.—Tapping a hydrocele (Greene and Brooks).

behind by the left hand, thus pushing the sac forward and making the skin tense. A spot free from large veins is selected on the anterior surface of the upper two-thirds of the scrotum, and a trocar and cannula introduced with a quick thrust. It is well to place the finger and thumb about one inch from the point, to act as a guard in order to avoid wounding the testicle. The trocar is then withdrawn, the fluid evacuated, and the irritant injected by means of a syringe. If carbolic acid is used, about 10 to 100 minims of the pure liquefied acid,

according to the size of the hydrocele, are injected, and the needle immediately withdrawn. The operation is absolutely bloodless and almost painless. If iodin is used, one dram to one ounce of the pure tincture is injected, depending upon the quantity of fluid withdrawn; the iodin injection is much more painful than the carbolic acid, and no more efficient. The patient should remain in the recumbent position for twenty-four hours, and may require certain anodynes or local soothing measures for the inflammatory reaction.

Suprapubic Puncture of the Bladder.—This operation is performed for the relief of an acutely distended bladder, where it is impossible to

Fig. 227.—Suprapubic puncture of the bladder (Mumford).

introduce a catheter by reason of a tight stricture or other cause. It should be remembered, however, that the introduction of a filiform bougie is sufficient, if left in place for some hours, to empty the distended bladder. If nothing can be introduced, however, and perineal section is not thought advisable, the bladder must be punctured to evacuate the urine.

Method.—The hair on the pubic region should be shaved, and the skin carefully cleansed with soap and water, alcohol, and lightly brushed with tincture of iodin. Under local anesthesia a puncture is made in the skin in the middle line, just above the pubis, and a

trocar and cannula thrust directly backward until it enters the bladder, which can be told by the sudden cessation of all resistance. The trocar is then withdrawn, the urine slowly evacuated, and a rubber tube attached to the cannula for permanent drainage, or the instrument withdrawn and the wound sealed with gauze and collodion.

Paracentesis of the tympanic membrane is performed for the purpose of evacuating secretions retained behind the drum in acute catarrhal and other inflammatory affections of the middle ear.

Method.—The external auditory meatus must be carefully cleansed by syringing with a warm solution of bichlorid of mercury (1 : 4000), hydrogen peroxid, or equal parts of alcohol and boric-acid solution. The external ear should be thoroughly cleansed with soap and water, followed by alcohol or bichlorid solution. The drum must then be anesthetized, or a general anesthetic given, as the pain of cutting the inflamed membrane is often exquisite. Equal parts of absolute alcohol and anilin oil, to which cocain is added (10 to 20 per cent.), is recommended by Gray for this purpose. In case of children or nervous adults it is probably better to use chloroform or nitrous oxid, although the latter should not be used in a young child, owing to its danger.

The canal is dilated with a speculum, the drum exposed and illuminated by some reflected light, and the paracentesis knife introduced through the speculum. This is thrust through the membrane at the highest point of bulging, the cut extended downward, and the knife withdrawn. This incision should not be a puncture, but should be large enough to allow for temporary drainage of the cavity, as healing nearly always occurs, no matter what size the incision made. The evacuation should be followed by inflation in order to drive out the exudate through the opening into the auditory canal, but syringing the external auditory meatus should not be practised.

SOUTHEY'S TUBES

Edema of the lower limbs in chronic heart or kidney affections may cause pain and discomfort and fail to respond to general treatment. In such cases relief may be obtained by making multiple aseptic incisions or by the use of Southey's tubes. Edema from weak veins and varicose veins may predispose to leg ulcer, and the latter fail to heal until the edema subsides. In such cases the tubes may be used if elevation and bandaging fail to move the serum out of the leg.

The apparatus consists of a trocar and several cannulæ, the latter having lateral openings at their distal ends. After careful cleansing of the skin with soap and water, alcohol, and tincture of iodin, the skin is punctured at right angles to the surface and the trocar and cannula pushed as far as the muscle tissue. The trocar is then withdrawn and the cannula fitted to a piece of rubber tubing which drains into a receptacle. Three or four cannulæ may be introduced in this manner, and should be supported by gauze packed around them. The serum often clots in the tubes and interferes with the drainage.

THE INJECTION OF BISMUTH PASTE

Mostly through the efforts of E. G. Beck, of Chicago, a method of diagnosis and treatment of fistulous tracts, tuberculous sinuses, and abscess cavities, including empyema, has been introduced recently which seems of decided value. The method is based on the fact that bismuth subnitrate is a bactericidal, chemotactic, and astringent substance, which is slowly absorbed and slowly eliminated. The mechanical action of the bismuth is also said to be a prominent factor in the healing process, as it separates the walls from one another, and later forms a framework for the proliferating fibroblasts to work through. Toxic effects have been observed in some cases, and are those of nitrite poisoning, ulcerative stomatitis, black line on the gums, cyanosis, acute nephritis, and collapse. If they develop, the paste should be at once softened and washed out with olive oil, but no cureting should be done. The paste should not be used in sinuses where there is danger of pressure on vital organs, such as the brain or pancreatic ducts, and death from embolus would probably result if any of the paste entered a vein. It should not be used to fill up a tuberculous joint.

Method.—The paste consists of arsenic-free bismuth subnitrate, 33 per cent., and vaselin, 67 per cent., the former stirred into the vaselin while hot, but not boiling. Just before using it should be heated and thoroughly stirred until thin enough to be drawn into a syringe. No water must be used, and the mouth of the sinus should be wiped off with alcohol. The syringe, which must be strong and fitted with a blunt nozle similar to that of a Valentine irrigating tip, is filled, pressed against the sinus, and the paste slowly injected until the patient complains of distention. A pledget of gauze is then pressed against the opening, and an ice-bag applied for a short time, the patient remaining quiet for a few hours. The secretions should change in character and become seropurulent, then serous, and finally disappear. If they persist, a second injection is made at the end of a week, and repeated every three to five days until the sinuses close. If at the end of two or three months no improvement occurs, the cause of failure, often a sequestrum, should be searched for.

INJECTIONS FOR NEURALGIA

Trifacial Neuralgia.—For a number of years various drugs have been employed for injection into the branches of the trigeminal nerve in the effort to cure tic douloureux. Chloroform, osmic acid, and alcohol are the only ones which have given any degree of success. In 1900 Schlösser showed that the injection of a few cubic centimeters of 80 per cent. alcohol into a sensory nerve caused complete numbness and anesthesia, lasting for a variable length of time, after which normal sensation returned without previous pain. He inserts the needle into the foramen and makes the injection. In 1906 Lévy and Baudouin

proposed the following method, which, in the hands of Patrick and others, has been productive of brilliant results. The prognosis for cure in a permanent sense is not good, but complete palliation after one or several injections may be expected, and recurrence appear in from six months to one year. In some cases apparent cure has been obtained.

Injections are made with a long straight needle fitted with a stilet or obturator, the blunt end of which is flush with the needle-point. The distal end of the needle is marked off in centimeters up to 5. The solution used is alcohol (85 per cent.), with 4 grains of cocain to the ounce. The original formula called for morphin and chloroform, but Patrick has discarded these at the present time.

The site of injection varies with the particular division of the fifth nerve which is the seat of the neuralgia. In the case of supra-orbital neuralgia, the injection should be given along the course of the nerve, at the supra-orbital notch; deep injections for this nerve have proved dangerous and have been abandoned. If the second division is involved, the alcohol should be injected at the point of emergence from the foramen rotundum and in the pterygomaxillary fissure. The posterior edge of the ascending (orbital) process of the malar bone is located, and its line prolonged downward to the inferior edges of the zygoma; one-half centimeter posterior to this point is the place for puncture. The needle is at first introduced in a direction vertical to the anteroposterior diameter of the head, and then slightly upward until a depth of 5 cm. has been reached, when the injection is made. Sometimes at a depth of about 2 cm. a bony obstacle is encountered, the coronoid process, necessitating the removal of the needle and its reintroduction at a point further forward, in which case the direction is changed from a vertical to a slightly upward one, but care must be taken not to enter the orbit. At a depth of 4 cm. the pterygoid plate may require some manipulation of the needle before the fissure can be entered, but the depth of 5 cm. must not be exceeded. The third division is reached at the base of the skull, where it emerges from the foramen ovale. A point 2.5 cm. in front of the descending root of the zygoma and along its inferior border is ascertained, and the needle thrust almost vertically to the depth of 4 cm. It is better to slightly incline the point upward until the bone is reached, and then work down to the nerve.

Method.—After thoroughly cleansing the skin as though preparing for a surgical operation, the point for puncture is frozen by means of the ethyl chlorid spray, or anesthetized by a drop or two of a 4 per cent. solution of cocain injected into the skin. The sharp point of the needle is then thrust through the skin and the stilet pushed into place; the needle is then slowly thrust in the proper direction until the nerve is reached, at which point the patient should complain intensely of sharp, shooting pain, referred to the upper or lower jaw, teeth, tongue, etc. The stilet is then withdrawn rapidly, the syringe fitted to the needle, and the injection made. The needle is then withdrawn, and

firm pressure made over the point of puncture for some minutes, as there is often sharp oozing, after which a bit of gauze is sealed on with collodion. There is some swelling of the side of the face, as a rule, for the first few hours after the injection, but it rapidly subsides.

During the operation the patient's head should rest on the side with the transverse diameter exactly vertical. A hard pillow is almost essential.

The injection may have to be repeated several times, and should give relief for a period of some months, especially if analgesia of the affected area appears after the operation.

Sciatica.—This painful affection may be relieved in two-thirds of cases by the injection of physiologic salt solution into the sheath of the sciatic nerve; the injection aims to detach the adhesions that have formed around the inflamed nerve. The method should not be applied to acute cases, as these yield to rest with physical and medicinal treatment.

A thin needle with a mandrin, similar to a spinal puncture needle, and 10 cm. long, is introduced into the tissues of the thigh at the point where the long head of the biceps is crossed by the lower edge of the gluteus maximus muscle. The needle is thrust in at right angles to the thigh for 5 cm., and then slightly upward for about 3 cm. further, when it should encounter the nerve and be made enter its sheath. The salt solution is then injected by means of a strong syringe until about 120 c.c. (4 ounces) have been given. The injection may be repeated. The patient should be placed in the knee-elbow position and supported, and it is needless to state that full aseptic precautions should be observed.

SALINE IRRIGATIONS AND INFUSIONS

The use of physiologic salt solution for various medical and surgical conditions has become so universal that it may be considered a routine procedure. It is invaluable in the treatment of anemia due to acute hemorrhage, and in such an event should be administered intravenously. It is often of great value in shock, but if the peripheral resistance is lost, no amount of transfusion can more than temporarily restore the blood-pressure, and death is certain (Crile). If the shock is more increased by regional accumulations of blood in the splanchnic area, as is the case in shock following abdominal sections, transfusion is often effective, peripheral resistance still being present (Crile). In peritonitis the use of salt solution by proctoclysis has proved invaluable. In general infections it may be used to stimulate resistance, support the circulation, and encourage elimination, but often fails to exert an appreciable influence. In carbon monoxid and in illuminating-gas poisoning it should be used after venesection.

The solution usually consists of sodium chlorid in water, 0.9 in strength, thus agreeing with the tonicity of the blood. It is not, however, a true physiologic solution, and is not ideal, since other inorganic substances—potassium, calcium, and magnesium—are also

present in the blood. One of the most widely known solutions used in experimental work is that of Locke:

Sodium chlorid	0.900
Potassium chlorid	0.025
Calcium chlorid	0.023
Sodium bicarbonate	0.020
Glucose	0.100
Water	98.932
	100.000

Adler recommends a physiologic solution which closely approximates the blood-serum in its constitution, and provides a mechanism for maintaining its reaction and for neutralizing acids and alkalis. It is made up as follows:

Sodium chlorid	0.5900
Potassium chlorid	0.0400
Calcium chlorid	0.0400
Magnesium chlorid	0.0250
Sodium phosphate (NaH_2PO_4)	0.0126
Sodium bicarbonate	0.3510
Glucose	0.1500
Distilled water	98.7914
	100.0000

Recently, Thies has called attention to the danger of saline infusions, especially when the alkaline metals in the cell are substituted by the sodium chlorid. He states that the potassium and calcium salts are directly essential for the vital functionating of the cell, hence the infusion should be composed of these salts in proportions corresponding to those in the normal tissues. He especially warns against the indiscriminate infusion of pure normal saline solution in small children, and in conditions in which there is retention of sodium chlorid or increased elimination of other salts, hence in all febrile conditions. Exactly what may happen when the artificial serum does not agree with the blood as a whole has not been definitely determined, but clinically one sometimes observes evidences of toxemia with rigors, bloody diarrhea, hemoglobinuria, and respiratory difficulties. We do not know whether hemolysis is induced by the salt solution, but it seems probable that some alteration of the corpuscles may occur if the solution is not isotonic with the blood.

As a rule, however, the widely used 0.9 solution of sodium chlorid is extremely efficacious and easily obtained when wanted in an emergency. It is prepared by adding 9 grams of sodium chlorid to a little boiling water obtained from the hospital sterilizer, and then sterilizing the solution by boiling in a glass flask. In private practice the tap-water should be filtered through gauze and boiled for one-half hour. For emergency use the manufacturers of surgical supplies put up the salt, already sterilized, in tubes which are simply emptied into a quart of boiled water. The use of the teaspoon to measure the salt should

be dispensed with. There are three methods in common use for the administration of normal salt solution:

1. **Hypodermoclysis.**—The subcutaneous method of giving saline solution has little to commend it but simplicity. The injection is usually made in the subcutaneous cellular tissue of the breast, and requires only a large, sharp-pointed hypodermic needle, some rubber tubing, a funnel and pitcher, or a fountain syringe, which must be sterilized by boiling before using. The skin should be carefully cleansed with soap and water and alcohol, and after testing the apparatus to see that it is filled with solution at 110° F., the tube is pinched and the tissues of the breast drawn up with the left hand. The needle is plunged into the outer lower quadrant, and in an upward

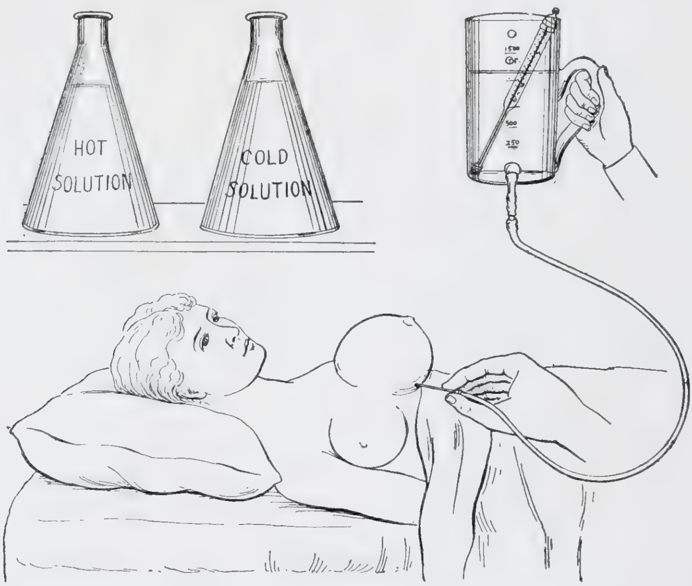

Fig. 228.—Giving hypodermoclysis under the left breast (Ashton).

and inward direction; the fluid then gradually runs in, and should not enter the tissues much faster than absorption takes place. If introduced too rapidly, the part bulges, the skin becomes smooth, white, and tense, and sometimes pain is complained of. If bulging occurs, the part should be gently massaged and the needle shifted several times. After about a quart has been given, the needle is quickly withdrawn and the puncture sealed with gauze or cotton and collodion. If allowed to run very slowly,—six or eight ounces in an hour,—the infusion may be kept up continuously. Sometimes the injection is given in the loin or thigh. Infection, introduction of air, puncture of a thoracic vein, or penetration of the pleura are dangers to be avoided. If the circulation is not efficient, the fluid will not be ab-

sorbed at all, or very slowly, and hence the method has a very limited field.

2. **Intravenous infusion** (transfusion) is the most useful of the various methods for giving salt solution, and the only one worth while in the treatment of shock from hemorrhage. The technic is not difficult unless the patient is very restless. The apparatus required consists of a metal cannula, three feet of rubber tubing, and a glass funnel or glass container or fountain syringe. The cannula should have a slight bend in it, and have a bulbous extremity at one end,

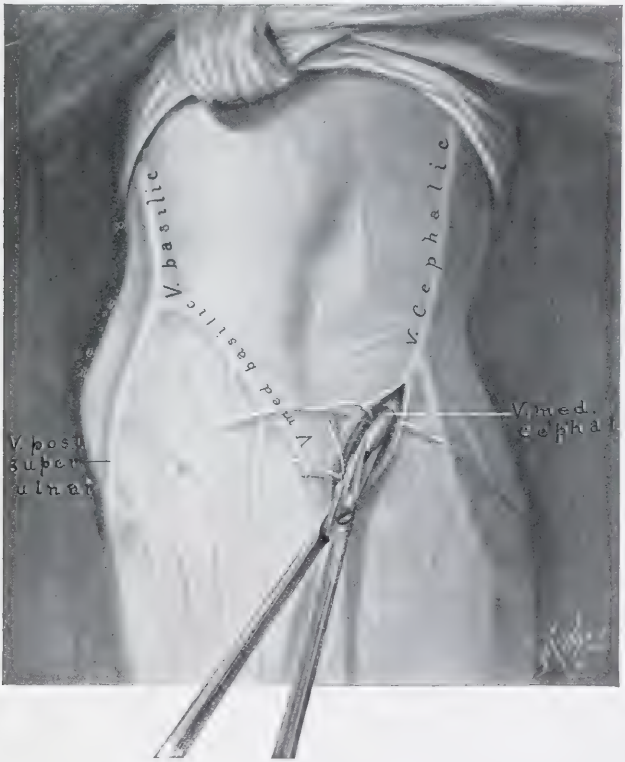

Fig. 229.—Mode of snipping vein to admit nozzle of infusing tube (Dorsett).

and a flange at the other, the rubber tube being securely tied to the latter before commencing the operation. An ordinary exploring or aspirating needle will do in an emergency. In addition a scalpel, forceps, scissors, director, silk, and a needle are required. The median basilic or cephalic veins are usually used, but if very small and hard to find, the internal saphenous vein is more satisfactory. The apparatus should be sterilized by boiling, filled with salt solution at a temperature of 105° F., and free from air-bubbles or floating cotton. It should be held in readiness by an assistant. The instruments should also be sterilized. The skin just above the bend of the elbow is rapidly

cleansed with soap and water, and alcohol and several turns of a bandage (fillet) passed around the upper arm to constrict the veins. A longitudinal incision, one-half to one inch long, is made over the vein until it is exposed, freed from its sheath, and lifted on the director. Two silk ligatures are passed with the forceps beneath the vein and the lower one securely tied; the upper ligature is tied in a loose single knot about one-half inch from the vein, and used as a tractor to lift the vein up. The vein is then cut half-way through with the scissors—the points must be sharp—and the cannula from which the saline *is escaping* pushed into the opening and upward in the lumen of the vein. The assistant then steadies the cannula while the operator ties the knot down on it. The tourniquet must then be cut or removed, and, by raising the container, the rate of flow is increased. If there is any delay in exposing the vein, the solution must be allowed to run out of the rubber tubing, if it has cooled, before introducing into the vein; this can be controlled by spraying on the back of the hand. Care must be taken to see that the cannula is introduced *into* the vein, and not between the vein and its sheath. The temperature should be ascertained by means of a thermometer, or, lacking that, should just feel warm to the back of the operator's hand. If a funnel is used, the attention of the assistant must not be diverted from it, otherwise it may suddenly empty and air-bubbles enter the vein, which, if large in amount, may cause death from air embolus.

The solution should be injected at the rate of a pint in ten minutes, and no more than two or three pints given at a time; if introduced too rapidly, cardiac dilatation may occur, and if in too large quantity, serous transudates take place. In shock with low peripheral resistance the effect of the injection may be much enhanced by filling a hypodermic syringe with 10 minims of a 1 : 1000 solution of adrenalin, and, puncturing the rubber tube obliquely with the needle, slowly pushing the piston down. In this way the adrenalin is given into the vein largely diluted by the salt solution.

At the conclusion of the operation the knot of the ligature should be loosened, the cannula withdrawn, and the ligature retied with a double knot. The wound is then sponged out and closed with a few silk sutures, after which a gauze pad and figure-of-eight bandage are applied. The infusion may be repeated several times if necessary.

3. **Enteroclysis.**—The introduction of a quart of salt solution into the rectum and colon, with the patient in the Trendelenburg position, is routinely practised by some surgeons at the close of major operations. It is said to relieve thirst, promote elimination, and minimize shock. After the patient has been returned to bed, the method is useful when the degree of shock is not very severe, or after an intravenous infusion when we want a continuous effect. A rectal tube is introduced for a distance of six inches, and about one pint every two or three hours, at a temperature of 110° F., and introduced slowly with a fountain syringe or Davidson syringe, should be given. An ounce of brandy may be added to the pint of salt solution if deemed necessary.

Continuous Proctoclysis.—The continuous method of giving saline solution by bowel is generally spoken of as Murphy's method. It is by far the most scientific and the most successful method of giving continuous enteroclysis, especially in the treatment of suppurative conditions of the peritoneal cavity. As a rule, the treatment is not instituted in the way advised by Murphy, partly because of ignorance of details and partly because of certain difficulties, unless close attention is paid to the details.

The apparatus for administering the fluid consists of a fountain syringe or can to which is attached a large rubber tube fitted with a hard-rubber or glass vaginal tip with multiple openings. The latter should be flexed at an obtuse angle, 2 inches from its tip, in order to prevent pressure of the posterior wall of the rectum when the patient is in the Fowler position. This may be done by heating the tube in an alcohol flame and bending to the required angle. The tube is inserted into the rectum until the angle fits closely to the sphincter, and is secured in place by adhesive strips binding it firmly to the thigh. The container may be fastened at the foot of the bed, in which case the rubber tube is passed under the bedding between the legs, or if fastened to the side, care must be taken to see that the leg does not press on the rubber tube. The container should be suspended so that its base is 6 inches above the level of the patient's buttocks; neglect in this point in the detail will insure failure. The container should be raised just sufficiently to overbalance hydrostatically the intra-abdominal pressure, so that the rectum and large intestine are moderately distended. If these are hyperdistended, muscular spasm and expulsion of the fluid result, and if the container is too high, or if the rubber tube has been pinched by a stop-cock, the fluid will be expelled around the tube into the bed. If the height of the container is just sufficient to overcome intra-abdominal pressure, the expulsion of gas or other fluid will take place through the rubber tube back into the container, and a few minutes later, when the irritability has subsided, the pressure will again be just sufficient to keep the bowel merely distended. The salt solution should be kept at a temperature of 100° F., by means of heat in the form of hot-water bags, or by means of an apparatus such as those invented by Saxon, Magnuson, Elbrecht, etc. The average

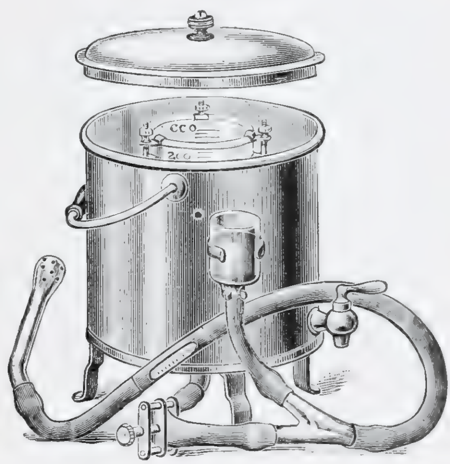

Fig. 230.—Saxon's apparatus for proctoclysis.

quantity administered should be from 12 to 20 pints in the twenty-four hours, and should be continued for three days. One and one-half pints of the saline solution should be placed in the container every two hours, and this should flow into the rectum in from forty to sixty minutes. Occasionally it will be found necessary to elevate the container to a higher point than 6 inches in order to obtain sufficient pressure for absorption, but, as Murphy states, the fluid "should never have a headway of more than fifteen inches' hydrostatic pressure, and it gives the best and most uniform results at four to seven inches." Unless the proctoclysis is not working satisfactorily, the container need not be disturbed for several days, nor need the rectal tube be removed.

GASTRIC LAVAGE

Lavage, or washing out the stomach, is indicated in chronic gastritis where there is either an excessive secretion of mucus or fermentation of the food, in gastric disturbance in children, in gastrectasis, etc., and in surgical practice, where vomiting persists as a postoperative complication, or where the stomach is filled with regurgitating and often fecal material, as in peritonitis or intestinal obstruction.

Lavage is performed by means of a soft-rubber tube in one end of which are several openings or windows. The tube should be about 30 inches long, and may then be connected by means of a glass or rubber junction with another piece from two to three feet long, to the end of which a rubber funnel is attached. These stomach-tubes are sold both with and without a bulb in the middle, and while not at all necessary, nor even recommended by some authorities, yet the bulb is useful at times to start the siphonage. If the lower end of the tube is closed, it should not have a long culdesac below the lowermost lateral opening, as particles of food are apt to accumulate therein and render it difficult to keep the instrument clean.

The tube should be carefully cleansed and disinfected after it has been used, and in private practice the patient should have his own tube, if possible, but in any case tubes that are used in patients suffering from cancer, syphilis, or tuberculosis, should not be used for other patients.

Method.—A rubber sheet should be thrown over the chest and well tucked around the neck. The patient is then carefully instructed as to what is to be done, and after opening his mouth, the tube wet with water, never greased, is introduced into the posterior pharynx, and the patient instructed to swallow; as the tube passes the glottis coughing usually takes place, but it is only momentary, and is relieved by the patient taking deep inspirations. As the patient swallows the tube is pushed backward and enters the esophagus, just as a morsel of food would, and is then pushed slowly but rhythmically downward until the stomach is reached, the patient being instructed to breathe rather deeply and regularly. As the tube enters the stomach

gas escapes with a gurgling noise through the funnel, and may be followed at once by the contents of the stomach; the funnel is then placed at a lower level than the stomach, and the contents allowed to flow into a receptacle. When the stomach has been emptied, the funnel is raised above the level of the mouth and filled with warm saline solution or sterilized water; the fluid runs through the tube into the stomach, and after eight or ten ounces have been introduced, the funnel is again lowered and the contents evacuated, this being continued until the returning fluid is clear.

There are several points in the technic of introducing the stomach-tube which make the operation less objectionable to the patient. It

Fig. 231.—Lavage, first step. Introduction of tube (Crandon).

Fig. 232.—Lavage, second step. Tube in stomach. Wash-water being poured into funnel (Crandon).

is well to place the tube in ice-water for some minutes before its introduction, as gagging is thereby lessened; in patients who are particularly sensitive the mucous membrane of the pharynx may be sprayed with a 5 per cent. solution of cocain before introducing the tube, but this procedure is rarely necessary. Artificial teeth should be removed before admitting the passage of the tube, and the latter should not be cracked or weak, as cases have been reported where the stomach-tube has parted, a portion of it passing down into the stomach, necessitating gastrotomy. If the tube is introduced with the patient in the sitting posture, the head should be slightly flexed. The tongue should never be depressed with the fingers of the left hand while introducing the tube with the right, as it causes the patient to

involuntarily hold his breath or to vomit. There is practically no danger of entering the larynx instead of the esophagus if one engages the end of the tube by the act of swallowing; the cyanosis that occurs so commonly is due to the spasmodic holding of the breath, and immediately clears up when the patient obeys the command to breathe deeply and regularly.

In cases of chronic gastritis the epigastrium may be massaged during the procedure, and bicarbonate of soda solution (1 : 200) should be used to facilitate the removal of the mucus. When fermentation is present, the stomach may be washed out with some mild antiseptic solution, such as potassium permanganate (1 : 10,000) or salicylic acid (1 : 1000).

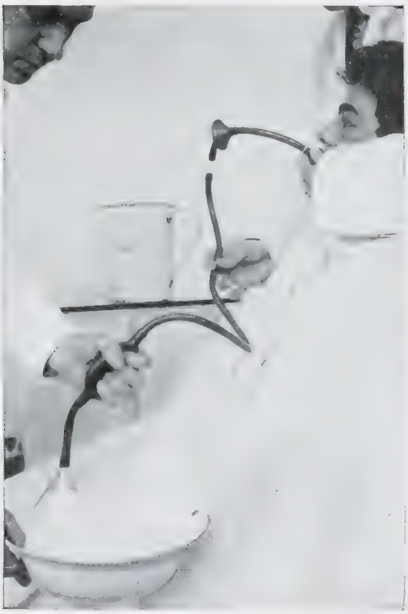

Fig. 233.—Lavage, third step. Suction and siphonage (Crandon).

In children, the child should be held by means of a towel passing around the body, holding the arms, and the mouth held open with a gag. A soft-rubber catheter (Am. No. 12, Fr. No. 18) is used as the stomach-tube, and is attached by means of a one-eighth inch glass tube to two feet of one-quarter inch plain rubber tubing, at the end of which a small glass funnel is attached. An extra opening may be cut in the catheter, about one-half inch from the original one, in order to allow for more rapid evacuation of the fluid. The tube is pushed to the back of the pharynx, and passes rapidly down the esophagus into the stomach, at least nine inches of the tube being required to reach the stomach. The amount of water introduced into the stomach at one time varies with the age of the child; in a baby of one week one ounce may be used, and at six months from four to six ounces, but it is rarely advisable to introduce more than the latter at one time.

GAVAGE OR FORCED FEEDING

Gavage, or the introduction of food through the stomach-tube, is useful as a means of feeding in obstinate vomiting in children, in severe illness, such as diphtheria, pneumonia, etc., and in extreme malnutrition and exhaustion, or in those under alcohol or opium narcosis. The tube is introduced in the same way as for lavage, milk, thin gruel, or broths, being introduced in appropriate quantities every four or six hours.

THE GENERAL CARE AND MANAGEMENT OF THE SICK AND THE TREATMENT OF SLIGHT AILMENTS

By M. Howard Fussell, M.D.

He who enters the practice of medicine must, if he wish to advance that great art, have but one ambition—to benefit mankind. He must make medicine his mistress in truth and obey her. He must desire to leave nothing undone which will help to solve a dark problem. In the practice of the art, if one wishes to succeed, the pleasure, the good, and even the whims of the patient, must take precedence over the doctor's personal desires. Every doctor should form an ideal and live up to it. Let the ideal be high; take the lives of men like Leidy, Gross, Agnew, Pepper, and live as near the ideal as possible and be content. These attributes of the physician are necessary:

(1) Truthfulness—a reputation for probity in ordinary every-day life goes a long way in making a doctor's practice successful. Truthfulness in dealing with patients and their ailments is equally necessary. Never exaggerate the seriousness of a patient's malady, for the purpose of alarming him or of having him obey orders. Put his case plainly before him. If he is severely ill, tell him so; but be careful that this very act of truthfulness does not in itself exaggerate. Endeavor to have the patient see his disease as you see it. To say abruptly to an individual, "You have heart disease," or "You have tuberculosis," is often, yes, usually, to so alarm the individual that all chance for doing good is lost. Convey to him that he has trouble with his heart or that he has tuberculosis, but do it in such a way that he may know and understand that neither heart disease nor tuberculosis is necessarily fatal. Show him the favorable side of his case first and gradually lead up to the serious side.

(2) Associations. Care in selection of one's associates is of the highest importance. The doctor who consorts with revelers, who is known to visit saloons and houses of ill repute, never obtains nor holds the respect and confidence of the public, much less of his patients. Not only is it necessary to avoid the company of roisterers, but great care must be exercised in what is popularly called "good" society, "the upper walks of life." As is known to all, errors of conduct cannot be glossed by mere acquaintance with the rich. This does not excuse drunkenness or licentiousness.

(3) Manners. The manners of the doctor should be the same to the poor as to the rich. One's best friends, those among whom we do the most good, are often numbered among the lowly. The washer-woman has as much right to courtesy, to respect for her secrets, to careful treatment, as her rich neighbor who rides by in the carriage.

See that she receives it. Nurses should be treated not as mere servants but as persons who have given much time and study to the accomplishment of ability to relieve suffering by the means taught them, often of as great or greater value than the ministrations of the physician himself. Yet they should be so trained by the practising physician that they learn not to overstep the boundary of nursing and assume the duties of a physician. Nothing is more helpful in the treatment of the sick than a good nurse who obeys orders. Nothing confuses the patient more nor irritates the physician to a greater extent than an individual who calls herself a nurse, but is constantly criticizing the physician or making suggestions to him.

(4) Equanimity. Nothing encourages the patient and the family more than the doctor who is calm in the face of danger, who has the ability to do quickly and accurately that which is called for in sudden emergency. The doctor who in the face of a sudden hemorrhage, for instance, is not ruffled, who gives his orders quickly and calmly, is sure to succeed in controlling that most alarming symptom, much better, much more quickly, and with less distress to the patient and to the family, than his brother who is excited, calls first for one thing and then for another. His own excitement is sure to be transmitted to his patient, and excitement on the part of the patient is one of the most harmful things which can occur to him.

Calmness under criticism is most desirable. Not a single physician goes through even a single day of his busy life without being criticized more or less unjustly. If one can save himself from blustering under such circumstances; if he will quietly inform the critic he has done his best and why; if he will become perhaps righteously indignant—then his dignity and his probity will be protected. Remember always that a patient has a perfect right to criticize, but also remember that his criticism is usually based upon entirely insufficient knowledge.

The patient's one idea, of course, is recovery, at least from any annoying symptom that is present. Until that is accomplished, he will not feel that he has received the attention due him. Therefore, however harsh and unjust the criticism of the patient may be, there is always the justification of an unfulfilled desire on the part of the patient. Other doctors will be quoted, other courses will be cited; under all this the doctor, I repeat, must maintain his calm exterior at least, whatever his actual feelings may be. If he is indignant at his treatment received, then let the language in which it is conveyed be dignified, but to the point.

General Knowledge.—The general knowledge that a physician possesses is often of extreme value in holding the respect and confidence of patients, particularly if the case be a chronic one. While the doctor wants, first of all, to be ready to deal with the case in hand, nevertheless he should be able to converse intelligently on the topics of the day, and on any subject of general import. Then, too, a "fad" which is used as a simple recreation and not as an occupation for the

doctor is of use in relieving the mental strain and directing the mind into other channels than medicine. No less important than these personal characteristics are the care in examination, diagnosis, and treatment of each case one is called to see. Indeed, these three essentials or three facts of the essential thoroughness should be personal traits of every physician. I believe that more errors are made by the physician because of carelessness of methods than are the result of lack of knowledge. Surely, by the constant exercise of care in going over every case much can be constantly learned, and some lack of knowledge remedied. In order to practise properly one should have a certain method of examining every patient. A history should be taken of every case in private practice and the notes of the progress of the case recorded. These histories should be filed. These notes can be taken upon the ordinary prescription blank, or upon a card cut the same size so it may be carried in the same receptacle and always be on hand. For this reason the writer has lately made use of his blanks, and he finds the notes are much fuller, because his blanks are always ready for use. This is of value, not only for keeping the various phases of the case well in hand, but for future reference, both for the purpose of an accurate knowledge of the conditions existing in the patient at some previous time, and for the sake of knowledge of the cases which the physician has treated. Notes are reminders, and he who is accustomed to their use seldom makes the egregious blunders so frequently made by the haphazard practitioner. Each individual organ in the body should be examined. If this were done, so many cases of pneumonia taken for appendicitis or gallstones for indigestion, and so forth, would not occur. The patient should always be stripped naked. Never venture an opinion upon the condition of a chest or abdomen which is covered with clothing. If the chest, abdomen, and limbs are examined naked, one sees and can examine what is seen. The examination of the urine should be done in every individual case. A diagnosis of nephritis, of diabetes, is of value in the beginning of the disease which can be discovered only by urine examination. It is of comparatively little value to make the diagnosis after edema, cardiac insufficiency, or convulsions have occurred. The blood should be examined in all obscure eases, the feces and stomach contents when indications suggest such examination. Every practitioner should be able to make such examinations. If the exigencies of his practice will not permit the time for such examination, then they should be made by men under his direction and should be reported to him and used by him. Certainly every practitioner should be able to interpret such examination. The interpretation should not be left to the assistant. Such examination of the patient as I have outlined is the basis of all correct diagnosis. A diagnosis cannot be surely made without such examination, or if it is made it is the result of a fortunate guess. The diagnosis proper is made by carefully weighing the facts elicited by the examination made as directed. There is no royal road to the diagnosis. It must

be the result of thorough knowledge of the particular case, and wide experience to allow the proper weighing of the facts in the case.

Obedience to Orders.—Perhaps one of the most difficult tasks set before the physician is to have his orders obeyed. Disobedience is frequently the result of ignorance on the part of the patient, misunderstanding the order given, or it may be due to interference by a third party. The first can be overcome by endeavoring to teach the individual the meaning of the orders given to him; the second is overcome by care in the giving of the order, in the actual demonstration of acts desired to be done by the physician himself, such as enemata, application of a mustard plaster, etc. It is a very simple thing for one trained to do either of these acts, but they seem complicated to those who have never attempted to do them. The third cause for disobedience can be overcome solely by gaining the confidence of the patient. Indeed, I believe that implicit confidence in the physician will overcome practically all these causes of disobedience.

Treatment.—As much care should be given to this part of our art as to making a diagnosis. While it is unquestionably true that no treatment can be of certain use without a proper diagnosis, a patient does not always see matters in that light. What he desires is relief. He does not care how scientifically or unscientifically it is procured. Treatment based on accurate diagnosis is frequently a simple matter. Just as frequently we have on our hands a condition which does not allow of any accurate diagnosis, and perhaps not of actual cure. Surely then we must give relief if possible. I have before said that one must endeavor to tell his patient the truth; by no means always just the condition which exists, but whether or not relief can be obtained and to what extent he can be relieved. From the fact that the very elite are frequently deceived as to the exact nature of an ailment, I believe that we are not justified in telling a person that his disease is incurable simply on a first examination, or indeed in many subsequent examinations; tell him that we will do what we can, realizing that many chances for mistakes consequently occur. Again, simply because we believe a case incurable, it is certainly wrong to fail to relieve the sufferings consequent upon the disease. None are more grateful for our offices than the friends of those just on the verge of death. Indeed, the patient himself is often full of gratitude for attentions at that time. They should always be given. On the other hand, no ailment should appear to us too slight for attention. I believe it is the duty of every physician to lead the mind of his patient into healthy channels, so that he may not be self-concentrated and constantly annoyed by slight ailments; but once a patient comes to you feeling that he is ill, he should receive dignified attention. Especially is this true of nervous, hysterical individuals. Of course, care must be taken that an organic lesion is not mistaken for a functional fault; then the patient must be plainly told that the ailment is fancied, or, what is much more likely, that as the basis there is some disturbing element which is causing the nervous palpitation, shooting pains, and

so on to the end of the chapter. A thoughtful, careful talk with a hysterical individual, especially in the beginning of the trouble, will frequently save a life-long subjugation to nervous ills, whereas the bluff remark, "You are nervous," and the administration of a placebo may confirm such condition. One must avoid, on the other hand, "nursing" a symptom. Tell the patient the whole truth as you understand it and a great part of the treatment will have been done.

If Drugs Are to be Administered.—Write your own prescription. Do not be coaxed or bullied into the use of myriads of ready-made formulas and proprietary mixtures. It is certainly an act of self-preservation on the part of the manufacturing chemist to say that his preparation is the best form of administering quinin or what not for the cure of certain disorders. Study the pharmacopeia and dispensatory, and usually you will find there what is necessary. Certainly none of the proprietary mixtures which are of any value come from outside the pharmacopeia. Constipation cures, fever pills, malaria cures, are but a degree removed from Green's Nervura or Lydia Pinkham's Compound. Administer the drugs in a palatable form. In these days of alkaloids and active principles and of capsules one need rarely give a nauseating dose. If necessary, however, to give a crude drug, do so, being careful to tell the patient that he will get bad medicine. Carelessness in these details has driven thousands of the unthinking to self-prescribing and to the various "isms." Endeavor to prescribe for the cause when possible; as rarely as may be for the symptom.

The performance of certain slight operations must be the daily practice of all physicians. These are discussed in detail in the chapter on Miscellaneous Therapeutic Measures; but I may perhaps again emphasize a few points. Hypodermic injections, used almost daily, may be the source of great discomfort, and even of danger, if not properly administered. The hypodermic syringe should be one which is capable of complete sterilization, quickly and without harm to the instrument. A solid metal or a glass barrel, a solid metal or a glass plunger, and a needle should be the only component parts. Such an instrument, if the needle is kept patulous, is always in order. It can be boiled in an ordinary metal cup, and is therefore safe. In regard to the necessity of sterilizing the hypodermic syringe, I have given hundreds of hypodermic injections without first sterilizing the instrument used, and by good fortune have never had any bad results; but I always sterilize now, for the reason that accidents have occurred, and I feel that we owe it to our patients that every care be taken that poison be not introduced through any act of ours. The instrument being sterilized, a measured dose, preferably one of the prepared hypodermic tablets, should be used. The skin is then cleansed with alcohol and the needle plunged deep into the tissue. If the hypodermic injection is one of the sera, then, as the dose is usually large, the injection should be made immediately under the skin, thus avoiding danger of an abscess from injury to the soft parts. Hypodermoclysis should just as carefully be made. It is best here to

have the solution sterilized several times, as is done in a well regulated hospital, in order to avoid infections, serious infections having frequently occurred. Lavage is so frequently used that a few words must be given as directions. The tube must first be boiled. It is then placed in hot water and immediately passed. The patient is directed to open his mouth; the tube is gently passed in until it touches the pharynx. The patient is then directed to swallow and gentle pressure is made on the tube during the act of swallowing. A new patient always has a tendency to stop breathing during the passage of a tube, and a constant reminder to breathe is often of the greatest value. Cocainization of the fauces may be advisable in individuals with irritable fauces, but it is rarely necessary. The tube being passed, a normal salt solution is poured in, and after about a pint is in the stomach, the funnel end of the tube is lowered until it is below the level of the stomach. If the water fails to flow, either the tube is stopped, coiled up, or perhaps is between or above the level of the liquid in the stomach.

The Sick-Room.—In these days of the gospel of fresh air and sufficient food and rest, little need be said to the physician as to their necessity. Much must still be taught to the laity, however, not only among the poor and needy, but in that class which can afford the luxuries of life, and which, therefore, is supposed to be better informed. Nothing is more common in all houses than the sight of a window or door closed to keep out the draft or the damp. A patient with pneumonia, typhoid, and tuberculosis is still kept in a closed room gasping for the much needed air that can be supplied only by the open window or open door. Let the room be well lighted—the best in the house. Nothing depresses the patient more than a dark sick-room. Quiet in the room, with few visitors, is about as necessary. When an individual is seriously ill, nothing is more natural than the desire of the family to be in the room. The sight of anxious faces, the vitiation of air needed by the patient, may be the factors which turn the scale toward fatality. Therefore, let the room have an abundance of fresh outside air. Let the patient be protected by sufficient clothing in order that he may not suffer distress or danger. This should apply in cold weather as well as in warm. If the patient is amply protected, the temperature of the room itself matters little.

THE TREATMENT OF SLIGHT AILMENTS

The term "slight ailments" is full of danger and quicksands to the unwary. Many cases of appendicitis have gone to their graves diagnosed indigestions. Tuberculosis in its early stages is constantly labeled a "cold." That there are slight ailments due to indiscretions of diet, changes in atmosphere, overexertion, mild infections, etc., is of course certain; and while it is a part of the physician's duty to be always on the alert to prevent himself from being deceived by "slight ailments," it is equally his care to reassure his patient when there is

no serious disease present. The element which is absolutely necessary that neither of these mistakes may occur is care in the examination of the patient, careful weighing of all the points of the case, knowledge and experience to be able to do these two things and the patient to carry them out. The mind of the physician should be entirely unprejudiced, never judging any conditions serious or otherwise until a careful diagnosis is made.

PAIN

Pain as a symptom must frequently be relieved entirely independently of the cause. It cannot be too strongly impressed upon our minds, however, that the relief of pain, while it makes the patient more comfortable, does not by any means cure the condition which causes the pain. It is a recognition of this fact which has caused surgeons to insist that opium be withheld from cases suffering from abdominal pain. Constantly a case of appendicitis has been allowed to progress to a gangrenous stage because the patient has been relieved by a hypodermic injection of morphin, and the physician has failed to take note of any symptom save pain. Certainly this sort of an attitude must never be entered into by the physician. It is frequently necessary to relieve pain in appendicitis, in pleurisy, in gall-bladder disease, indeed, in any condition where the pain is severe enough to greatly distress the patient or mask other symptoms. The diagnosis of the condition and the real state of the patient must not be lost sight of, even though the patient professes himself well. Indeed, it will not be lost sight of by the careful physician who takes note of all the physical signs and other symptoms than pain, even though the pain be relieved.

Because a hypodermic injection of morphin is so easily administered, and because it so promptly relieves pain from whatever cause, is one of the points of great value of the procedure; at the same time it is the reason for its abuse, or rather the failure of the doctor to make a diagnosis, and the cause of his being satisfied with what is often a desperate state of the patient.

It seems wise to speak of this method of procedure first because it is applicable, as has been stated, to relieve pain from whatever cause. A hypodermic injection should never be given carelessly. Hundreds of carelessly administered injections may be given, but if the habit is persisted in, sooner or later the physician will meet with disaster; local abscess, gangrenous areas, hemorrhagic areas may occur. I have seen an area of rapid gangrene with emphysema follow a hypodermic injection of morphin into a painful limb.

Therefore a sterile needle and sterile syringe should always be used; to this end either a glass syringe or a solid metal syringe should be used, because it is so much more easily sterilized by boiling; the needle should also be sterilized, and the tablet be dissolved in sterile water. It is better, for several reasons, to begin with a hypodermic injection of minimum strength. One-quarter grain has been known to prac-

tically narcotize a susceptible individual. If the susceptibilities be not known, $\frac{1}{8}$ grain had better be the initial dose.

Gall-stone colic and renal colic will always need large doses of morphin, even for temporary relief.

Appendicitis pain may often be relieved by the application of an ice-bag, but this must be only used temporarily, and the case put into the hands of a competent surgeon as soon as possible.

Pain due to distention of the stomach caused by acute indigestion may be promptly relieved by the administration of some aromatic and a small dose of opiate. A favorite prescription of mine is:

℞. Tincturæ opii camphoratæ..............f ʒiij
Spiritus ammoniæ aromatici,
Spiritus ætheris compositi...........āā..f ℥ss
Spiritus lavandulæ compositi ......q. s...f ℥ij
SIG.—One dram well diluted every fifteen minutes.

This mixture will do no harm, though care must be taken not to continue its use in unsuitable cases.

Headache, especially of nervous character, may be relieved by acetanilid administered in five-grain doses repeated half-hourly for four doses. When this remedy is used, however, the prescription must be under the direct control of the doctor; the druggist must never be allowed to refill the prescription without the doctor's order, because of the well-known habit-forming characteristic of the drug.

Pain due to a sore throat may be greatly relieved by allowing the patient to suck an abundance of ice, and by the application of ice externally to the throat.

The pain of earache may be relieved by the placing of a hypodermic pellet of atropin in the meatus, and filling the entire meatus with hot water.

Cocain will instantly relieve the pain of an inflamed conjunctiva, but care must be exercised here, however, because constant application is followed by a secondary hyperemia which may be harmful. Necessarily, any foreign body must first be removed.

Pain of toothache is relieved by the measures suggested in the chapter on Toothache.

Pleuritic pain may be almost instantly relieved by the use of wet-cups applied to the chest. The distress of a pleurodynia or the pain of a broken rib or contused chest may be greatly relieved by strapping the chest with broad adhesive strips. The straps should begin at the spinal column behind, and extend to one or two inches beyond the median line in front. They should overlap about one-fourth of their width.

The pain of an inflamed joint can be greatly relieved by rest and fixation of the joint. In the case of the hip-joint the effect on the pain of the application of a Buck's extension is magical.

There is a severe pain in the epigastrium which frequently occurs in pregnant women. This pain is often the first symptom of toxemia of pregnancy to attract attention. Great injury may be done the

patient and death may follow attempts to relieve this pain if its true character is not recognized. I have seen this symptom constantly mistaken and disaster follow. The pain is secondary, and its relief must always be embraced in measures leading to the relief of the toxic symptoms: sweating, bleeding, purgation. Observation of the degree of peripheral blood-pressure in a pregnant woman is of the greatest possible value. Given an epigastric pain in a pregnant woman with a high blood-pressure, there is a great likelihood of the case being one of toxemia of pregnancy.

Supra-orbital neuralgia may be relieved by a blister just above the supra-orbital notch and the administration of one massive dose of quinin.

Neuritis, when it gives rise to pain, as it so often does, demands rest and frequently the use of opiates. Occasionally great relief is obtained by the application of heat over the affected nerve. Salicylates are frequently of the greatest value.

FATIGUE

Acute Fatigue.—Acute fatigue the result of a sudden overexertion is necessarily more frequent in those suffering from acute or chronic illness than in those in perfect health. The feeling of weakness, dyspnea, cardiac palpitation, vertigo, and often threatened syncope demand immediate and often complete physical rest and removal of the cause of the fatigue.

The degree of rest and the length of time over which it shall be enforced will depend entirely upon the amount of actual physical disturbance. If the heart was dilated at first, or if it was irregular, both the dilatation, as shown by physical examination and subsidence of symptoms, and the arrhythmia must be allowed to disappear before exercise, even of the mildest degree, can be undertaken. If, on the other hand, the patient has a regular steady heart, he may be allowed to go about his duties as soon as the heart is steadied and he feels revived. If, on the other hand, the fatigue occurs in an individual suffering from either cardiac, renal, or pulmonary disease, great care, indeed, must be exercised and an abundance of time allowed to pass before the patient can think of going about for fear of a serious or even fatal collapse.

The first thought in the mind of the laity, and frequently the first thought of the doctor, is the administration of whisky or brandy. As years have passed in practice I find myself using less of alcoholic stimulants. Under the circumstances of acute fatigue, the secondary effects of alcohol are frequently so severe that the last condition is as bad as the first. In lieu of alcohol I give a hypodermic injection of $\frac{1}{150}$ grain of atropin and $\frac{1}{30}$ grain of strychnin. Inhalation of spirit of ammonia or the administration of aromatic spirit of ammonia will act equally well. Of necessity, the physician will not be satisfied by making a diagnosis of mere exhaustion, but

will see that any physical or functional fault which exists is treated if possible.

Chronic Fatigue.—Chronic fatigue is practically always the result of some chronic condition which causes the lack of response to normal stimulation. Overwork, due, of course, to long hours or excessive strain, is the commonest non-pathologic cause of being tired. Mill hands rise at any hour from 5.30 to 6.30, depending upon the distance of their residence from their mill. They eat or rather bolt a breakfast, work in a close mill, have half an hour's intermission for a lunch, and cease work at 5.30 or 6. The evening is likely to be spent in a theater or other close atmosphere. Such a life as this, day after day, year after year, causes a chronic tired feeling, with all its ill results. In many parts of the country a half-hour lunch is taken to allow of a half-holiday on Saturday. Much of the chronic fatigue is the direct result of this constant overwork. If mill-owners and the employers of the mass of workers could see ahead, they would find that well-lighted and well-ventilated rooms, with a possible lunch served at mid-morning and mid-afternoons, would so encourage, nourish, and keep up the spirits of their workmen and workwomen, and would so diminish the sickness among them, that the amount and character of work they could do would certainly pay for the extra expense, to say nothing of the spirits and health of their employees.

Slight but continuous hemorrhage, such as occurs in uncinariasis, uterine hemorrhage, and hemorrhoids frequently makes the patients so weak that they cannot well continue their ordinary work, though they may not be confined to bed. Weakness is their one complaint. Obviously, the proper treatment is relief of the condition, removal of parasites, treatment of the local condition, etc.

Pernicious anemia has being easily tired as one of its first symptoms. Examination of the blood and the exhibition of large amounts of arsenic are the proper remedies, together with rest and an abundance of nutritious food.

Early tuberculosis of the lungs or other organs, unattended by marked local symptoms, may have exhaustion as the cardinal symptom. Hence the imperative necessity of careful physical examination of the lungs, glandular and nervous system. The patients should be placed upon tonic treatment in the open air, with an abundance of nutritious food, with careful after-treatment as to hygiene. Lack of nervous stamina—neurasthenia—is a common cause of fatigue. One must be careful that tuberculosis or other physical ailment is not overlooked. When the diagnosis is made fairly certain, the Weir Mitchell rest treatment, carried out as he directs, will often transform a patient who cannot stand any work or excitement into a strong, robust individual.

In a word, the treatment of fatigue depends absolutely upon diagnosis. Simple tonics, the administration of iron, and other common measures are valueless, unless the condition of the body actually needs these drugs.

"CATCHING COLD"

No term is used among the laity more frequently than is this. My belief is that every "cold" is due to an infection from some organism of greater or lesser virulence. Certain it is that an individual may be in apparently excellent health, and as the result of extra exertion, undue worry, or some trying circumstance, the vitality of the body is lowered, and an organism, probably always present in the air-passages, takes on sudden growth, its toxin is developed, and, presto, we have chilly sensations, fever, aching limbs, coryza, cough—symptoms not possible to distinguish in the first hours from an attack of influenza, beginning pneumonia, etc. The condition frequently ends in a few hours with the appearance of profuse perspiration, or it may drag on for days with a persistent coryza, bronchitis, and indigestion. The great danger of this condition is in the haphazard way of treating it as "nothing but a cold." The patient should surely be put to bed for the first twelve or twenty-four hours. A successful method of treatment is to open the bowels, either with a bottle of citrate of magnesia or with ¼-grain doses of calomel, repeated every hour until twelve doses are taken, and the following prescription given:

℞. Salol..ʒj
Phenacetin..gr. xxxvj. M.
Fiat chart. No. xii.
Sig.—One every two hours.

Usually within twelve hours the patient will be in a profuse perspiration and will be feeling practically well. I am quite sure that if we could persuade all our patients to remain in bed for the twelve or twenty-four hours with such an attack, we would have fewer of the cases dragging on with distressing cough or obstinate coryza. Particularly is recovery prevented during the winter and fall months by lack of rest in bed. Certainly, such cases often drag on until finally a true pneumonia develops.

Occasionally, in addition to the above prescription a mixture is necessary to allay the cough. This is particularly the fact when the patient is unable to remain in bed. A prescription of which I am particularly fond under these conditions is as follows:

℞. Codeinæ sulphatis..gr. iss
Potassii citratis..ʒ iss
Succi limonis..ʒ ss
Syrupi..q. s. fl.℥iij. M.
Sig.—ʒij every two or three hours.

I think that codein is preferable in the mixture to heroin. The latter drug has been in my hands particularly uncertain in its effects. Sometimes $\frac{1}{12}$ gr. has no effect, and in certain individuals it causes a decided narcosis. The old prescription of Dr. George B. Wood, to hang a hat on the bedpost and drink whisky toddy until two

hats are seen, and then retire, may be just as efficacious as the above outline, but it has a too seductive side. If the individual is a child, the codein in the last prescription may be entirely omitted or it may be replaced by an appropriate dose of paregoric. In such a case as this it is certainly wise treatment to keep the patient in bed until the temperature is entirely normal. Many cases of typhoid and other serious conditions are constantly looked upon as a "cold" during the first few days of their beginning.

SORE THROAT

No condition is more full of danger or more harmful than a sore throat. Especially is this true when the patient is a child. Diphtheria and scarlet fever, two of our most dreaded diseases, have as one of their initial symptoms sore throat, while follicular tonsillitis, which is very usually a harmless condition, has sore throat as one of its important initial symptoms. And, again, a simply inflamed sore throat is part of a picture of a cold and influenza, etc. The first and most important point in these cases is the diagnosis. In no condition is this more necessary. The physician is seldom placed in a position where his judgment or the faith of the family are put to a more severe test. If the condition is diphtheria, the very life of the patient may depend upon prompt action. If the patient is suffering from fever, pain in the joints, headache, and the throat is dry, red, and painful, and there is no exudate, and particularly if the soreness is characterized by a "stiffness" in swallowing, the chances are that the condition is one of simple pharyngitis. If there is an exudate, four conditions are to be considered: Follicular tonsillitis, diphtheria, scarlet fever, and suppurative tonsillitis.

The sore throat which does not eventuate in any of the above conditions is characterized by extreme pain on attempting to swallow, and by bright redness of the pharynx, fauces, and tonsils. There is no exudate. The glands at the angles of the jaw may or may not be swollen and tender. This condition may, of course, be the forerunner of one of the more serious conditions. A simple alkaline spray, a normal salt solution, or the liquor antisepticus of the U. S. Pharmacopeia are usually grateful, and frequently necessary. For the joint pains which accompany this infection, nothing gives more certain or prompt relief than a powder of salol and phenacetin as recommended for a cold.

In order that sore throat of this kind may not be confounded with diphtheria in the early stages, I constantly use and earnestly recommend that throat cultures be made and examined. This procedure is simple. Culture-tubes can be obtained of any of the manufacturers of biologic products. If kept in a refrigerator, they will not deteriorate. After inoculating the tube, it may be cultured in a small oven, the temperature of which is regulated by a thermometer. After twelve hours the growth is spread upon a slide and

examined under a microscope with oil lens. I can attest to the practicability of this procedure being carried out by the physician in private practice. If, however, any physicians do not feel qualified to do the work, certain of the States, notably Pennsylvania, will do it at short notice gratis.

HOARSENESS

This may be, as is sore throat, the forerunner of a serious condition, or a mere simple laryngitis. If the condition occur during an attack of tonsillitis, it is pretty surely the result of a simple laryngitis. It can usually be relieved by inhalation of compound tincture of benzoin used in the following way:

Two drams of compound tincture of benzoin are put in a cup of hot water; the whole is then put in an ordinary teapot and the vapor inhaled though the spout. The inhalation should be practised every two or three hours. When the liquid cools, it can be reheated by placing the teapot containing the liquid in a vessel with hot water, thus avoiding changing the solution frequently. This manner of use is just as efficacious as the use of one of the various patent inhalers.

In children the onset of hoarseness fills both parent and physician with terror. If the child has been slightly ill and is awakened suddenly in the night with a loud, hoarse cough, and particularly if the throat is free from exudates, and, again, if the child in coughing or crying can utter a high note, the case can usually be diagnosed as catarrhal laryngitis, or spasmodic croup. On the other hand, if the child is slightly hoarse during the day, if the voice is muffled, if no high note can be made, and if an exudate can be seen in the throat, then one is pretty sure that the case is one of diphtheritic or membranous croup. The treatment of the former is by inhalation of steam, the administration of a mild emetic such as ipecac, and the administration of the following prescription:

℞.	Tincturæ opii camphoratæ	gr. xxxii	
	Tincturæ belladonnæ	gr. xvi	
	Ammonii bromidi	gr. lxxx	
	Syrupi tolutani	f℥j	M.
	Aquæ	q. s. f℥ij	

Sig.—ʒj every hour until relieved for a child two years old.

The only treatment for the membranous croup is the immediate administration of large doses of antitoxin, 4000 to 6000 units, and the use of intubation if the child is severely stenosed. One cause of croup and hoarseness is frequently not recognized by the practitioners, namely, laryngismus stridulus. This can be surely diagnosed by the chronicity of the case, the usual presence of rickets in the child, and frequently by the presence of Trousseau's sign, namely, the appearance of contraction of the finger and hand when firm pressure is made along the large vessels.

COUGH

Cough is of necessity only a symptom of laryngitis, bronchitis, pneumonia, pleurisy, or tuberculosis of the lungs. It may be caused by irritation due to adenoids or enlarged tonsil, or it may be only a reflex act due to irritation in some organ not connected with the respiratory apparatus. These causes will be discussed by the authors having the various chapters in hand, and cannot here be fully considered. Chiefly, however, I desire to call attention again to the necessity of care in examination of the patient, and to give what may be routine prescriptions for cases in which the cause cannot be discovered, but which nevertheless demand treatment. No error is more inexcusable, no act is more condemnatory, on the part of the physician, than, after listening to the history of the case, to say without an examination, "Oh, you only have a cold," and to prescribe a cough mixture. How many of us, after such an act, have been rudely awakened by suddenly discovering that our patient has an acute pneumonia, or pleurisy, or mayhap a beginning tuberculosis? The awakening is more rude if our mistake is pointed out to us by another physician. The remedy always at hand which will infallibly correct these errors is *care, care, care*, always repeated with your patient stripped to the skin. Never give an opinion—often an excuse for an examination—made with the clothing on the body. Symptoms which suggest an acute condition, such as a slowly beginning pleurisy or a latent pneumonia, demand rest in bed until the signs and symptoms disappear. A case in point is just now under my care. A young woman, a bookkeeper, applied to one of my friends for relief from weakness and a slight cough. Without any examination worthy the name, she was told she was "run down," and needed a tonic. Two weeks after I saw the patient with fever, a continuous cough, and marked dullness over the base of the left lung. This eventuated in effusion of considerable extent. It is, of course, possible that the effusion could not have been prevented, but at any rate the patient could have been at rest and not have risked her life by "exercising out of doors" for what was certainly an acute pleurisy. Every case should be carefully examined to these ends: Is the condition acute? If so, rest should be ordered at once. Is there some condition in the throat? If so, this should be remedied instead of giving the patient a stock mixture of perhaps questionable value. Still more important: Is there a beginning tubercular consolidation in some part of the lung? No question is pregnant with greater importance than this. If the patient is losing weight, if there is evening fever, if the heart is unduly rapid, and if there is a spot somewhere in the lung indicated by consolidation, then surely the case must be guarded and looked upon with suspicion as a probable case of tuberculosis.

Just here, however, I desire to digress and to impress the necessity of *care* in such a diagnosis. Just now, in 1911, when the great and undoubted necessity of early diagnosis in tuberculosis is

being preached on all sides, it is the fashion for *every* case such as I have described to be labeled tuberculosis *at once*. Especially is this the case when the symptoms I have described are accompanied by higher pitched resonance, increase in the volume of breath-sounds, and if the voice sounds at the *right* apex of the lungs. It has been taught for years (I propose to prove again, in another place) that these differences in the two apices are absolutely physiologic. It is quite as great a mistake to consider a cough accompanied by slight increase of signs at the *right* apex tuberculosis as it is to overlook an actual consolidation due to tuberculosis. While I believe every individual suffering from tuberculosis should know the character of his affection, I believe and practise with equal ardor that no one should be told he has tuberculosis on such slight grounds as I have last mentioned. Of course, every case of cough diagnosed properly tuberculosis should be treated by open air day and night. Exercise only when there is no fever, and then never to the point of exhaustion. Abundance of digestible food, best summed up perhaps in milk and eggs, in overabundance. The cough usually will respond to these measures, but if it chance that it does not, then an antispasmodic measure such as the following can be profitably given, it being distinctly understood that this is but a corrector for the symptoms and not a cure. Such a prescription as the following I have found efficacious:

℞. Codeinæ sulphatis........................gr. iij
Tincturæ hyoscyami........................f ʒ iij
Syrupi tolutani........................f ℥ ss
Aquæ........................q. s. f ℥ iij
Sig.—ʒ j every two or three hours.

Indeed, if the cough be hard and racking, whatever the cause, the writer has found the above remedy of value. If the case is one of laryngitis or bronchitis in the first stage, then the addition of citrate of potash or bromid of ammonia or both to the prescription is of importance, as in the following formula:

℞. Codeinæ sulphatis........................gr. iss
Potassii citratis........................ʒ ij
Syrupi tolutani........................f ℥ j
Aquæ........................q. s. f ℥ iij
Sig.—ʒ j every two hours.

Five grains of potassium or ammonium bromid to the dose may profitably be added to the above prescription.

HEADACHE

No symptom is more frequently complained of than headache. Again a thorough examination of the patient is necessary. Frequently the patient goes to the drug-store and purchases one of the various semi-proprietary medicines which are vaunted as sure cures. Usually

careful examination will clear up the case. One case has come under my notice with a severe headache lasting for a year or more. The pain came on at midnight each twenty-four hours and caused great distress to the sufferer. Examination showed much hyperacidity of the stomach contents. Regulation of the diet, together with large doses of alkalis after meals, completely broke up the paroxysms. The patient had taken headache remedies for years. Then we have the cases of migraine—typical sick headache—characterized by pain, more or less sudden, slowly or rapidly growing in severity, often completely prostrating the patient, then relieved by severe vomiting. Some such attacks are true "nerve storms," are a part of the nervous make-up of the patient, and are little relieved by any medication. Others are frequently the result of actual indiscretion, either in nervous strain, overwork, or diet. Such cases are best permanently relieved by a careful regulation of the habits of the patient. Care must be taken that no overexertion, either mental or physical, is undertaken, that no indigestible food is indulged in, that alcohol be let severely alone. For the immediate attack either a cold or a hot application to the head, sometimes the one and sometimes the other, gives relief. Lavage, which relieves the stomach of an immediate burden, has often in my hands given relief. Tincture of cannabis indica, given in full doses, will occasionally give relief. Perhaps the most useful, certainly the most popular, drug is a combination of acetanilid, caffein, soda, and camphor.

The great danger in administering such drugs lies in the popular use of the various headache remedies, which are largely such a combination. This is a real and not a fancied danger. The writer has seen and literature is full of many cases of chronic acetanilid poisoning, often of extreme severity. However, if the physician writes a prescription such as the following, and sees to it that the box of capsules is not renewed at the will of the patient, there will be little danger of doing harm. There can be no doubt that they frequently relieve a paroxysm. The prescription frequently used is:

℞. Acetanilidi .... gr. lxxij
Caffeinæ citratæ
Camphoræ monobromatæ .... āā gr. xij
Sodii bicarbonatis .... gr. xlviij
M. et fiat cap. xxiv.
Sig.—One every half-hour until six are taken.

There is little use of continuing the administration of the capsules if relief is not found soon after the six capsules are taken. I never write this prescription if I have any question that the orders in regard to the continual use of the capsule will be disregarded.

For the headache which follows a debauch there is no more efficacious method than lavage. A brisk purge with some saline and the administration of the following:

℞. Spiritus ammoniæ aromatici....................f ʒ iv
Ammonii bromidi.............................ʒ iij
Elixeris simplicis.........................q. s. f ℥ iij. M.
Sig.—ʒ ij every two hours in water.

For the headaches which accompany or precede the specific fevers there is relief to be found in the treatment of each special disease; the most important point being that these headaches are not misjudged and the patient treated for headache instead of being properly under treatment for the disease which causes the symptom. The headache which comes from eyestrain can be dealt with only by the oculist. It is a good habit, in every case of persistent pain in the head, where careful examination fails to show any obvious cause thereof, to have the eyes examined by a skilful oculist. I say skilful with reason. Many of our men outside of the cities, indeed those who are within the reach of a real oculist, are in the habit of sending their patients to one of the many opticians who measure for glasses. One may just as well send a patient to a drug-store for headache powders as a patient to an optician for glasses before he has been carefully examined by a skilled oculist. The habit of having the eyes examined for a cause of headache is particularly necessary, for very frequently the eye is the cause of the trouble when the patient claims to see perfectly and is entirely ignorant of any trouble with the eyes.

BACKACHE

Backache, as well as bilious attacks, and nervous attacks are conditions in which, *par excellence*, the diagnosis is the important factor in treatment. Backache depends for its cause upon so many different factors, each entirely independent from the other, that a diagnosis is absolutely necessary before treatment can expect to avail anything.

Caries of the spine may be diagnosticated by limitation of motion, tenderness over the spinal column at a given point, inability to bend the column normally, inability to arise to an erect position after stooping without artificial aid, girdle pains, a tumor over the spine; or by the use of the *x*-ray. Innumerable cases have become hopeless invalids by reason of a physician labeling such cases lumbago and administering some form of salicylate until cure without deformity had become an impossibility.

Iliosacral disease can be diagnosed by the localization of the pain over one or the other iliosacral joint, a slight mobility of the joint, or tenderness over it. The attacks may come on suddenly after stooping, during labor, after lying in one position after etherization (ether back). Here again physicians have for ages been treating such cases as sciatica or lumbago.

Girdle pains of tumor of the spinal cord or tabes dorsalis are constantly labeled backache because of hurried attempts or no at-

tempt at diagnosis. Pressure from thoracic or abdominal aneurysms or other tumors is constantly overlooked by reason of failure in observation. Enlarged kidney from any cause may give a decided backache.

Acute nephritis very occasionally gives rise to excruciating pain in the back, and must not be overlooked. In this connection I wish to remark that the layman affected with pain in the lumbar region almost without exception believes he has "kidney disease." As a matter of fact, the kidneys are very rarely responsible for backache. No such diagnosis should be made without careful urinary analysis.

Displacement of uterus, a uterine or ovarian tumor, constantly give rise to sickening backache. A gynecologist will set the matter straight. Here again the average woman with backache blames it upon her "womb." The doctor often abets this crime of diagnosis without a proper examination.

The more accurate diagnosis of these conditions may be found in proper volumes, and their treatment fully set forth in the various sections of this work. They are mentioned here that physicians may again be warned that a careful diagnosis is a necessary forerunner of any treatment worth the name, and that he may be warned that backache as an entity should be abolished from his thoughts.

Lumbago is a painful condition of the erector spinæ group of muscles; it may be diagnosed after all the aforementioned conditions, together with some others which space does not allow of mention, have been excluded. It may properly be treated with large doses of salicylate and by strapping the back. Occasionally puncture of the muscle group with a sterile needle will give relief.

EARACHE

How frequently one is called to a small child crying, restless with high fever, and careful examination fails to discover any lesion to account for what appears to be a most serious condition. Under such circumstances careful examination of the child's head will frequently show that there is much tenderness over one or the other ear when pressure is made over the tragus or when the pinna of the ear is gently pulled. If one is not thoughtful enough to do this, he is very likely, after a day or so, to find to his surprise that the child has a discharge from the ear, manifests much more comfort, but still may have considerable fever. The trouble from the beginning has been inflammation of the middle ear. Like all other diagnoses, there is no "royal road" to its success; it must be accomplished by painstaking observation. Usually, perhaps constantly, this condition is preceded by an ordinary coryza. The attention of the physician should be paid particularly to this condition, and the nasal cavity, indeed the entire nasopharynx, should be cleaned with an alkaline spray, and where the age of the individual will permit, with a cotton carrier moistened

in an alkaline solution, the nose and pharynx having first been made insensitive with cocain. Often the thorough cleansing of the nasal cavities and nasopharynx will cut short the attack of inflammation in the tympanum. Frequently, however, indeed usually, other measures must be instituted. If the patient is of sufficient age, a leech may be applied in front of the tragus, or the artificial leech recommended by Gleason in his book may be made use of. In addition iodin should be painted back of the ear over the exposed skin below the hair-line. That which gives perhaps the most immediate comfort is the application of artificial heat. Water as hot as can be borne should be poured into the external meatus and the ear covered with a cloth wrung from hot water or a hot-water bag applied over the entire ear.

If the pain is very severe, a hypodermic tablet of atropin may be dropped in the auditory canal, and dissolved *in situ* by means of hot water. Care must be taken that no larger dose be used in the ear than would be given by the mouth.

As to the choice of hot water or hot dry heat, the very hot water will give more prompt relief than dry heat; but if the application is to be continued for a long while, the dry heat is preferable, on account of the maceration produced by the water.

Oil, medicated or otherwise, *should never* be dropped into the auditory canal.

Very gentle syringing with very hot water will often give the first relief to the sufferer.

After the more acute pain is over, the whole region of the ear should be protected by a large pad of cotton. This should be worn when the patient first ventures outside.

The deafness, more or less severe, which is sure to follow an acute inflammation of the ear, is fairly sure to disappear upon use of manipulation of the drum through the tragus or insufflation by means of the Politzer bag.

Writers upon disease of the ear declare that with measures such as the foregoing the case may end in a simple catarrhal condition and no further trouble follow. As a matter of practical experience, however, suppuration of the middle ear may very frequently occur, and the case become a much more severe one of purulent otitis media. This is a much more severe condition, and may lead to dire results if the condition is not seriously treated. If the attack of inflammation of the ear occur in the course of an attack of measles, scarlet fever, or diphtheria, much the best policy is to call in the services of a specialist in case the attendant himself has not given special attention to the ear and throat. Indeed, the attempt on the part of the usual general practitioner to manipulate the treatment of the throat and ear is bungling indeed as compared with that of the well-trained specialist. In the emergency, however, one must always remember that the important point for treatment is the throat and not the ear. It is the throat where the trouble begins; and this must be treated if any

expected good is to come to the ear. The same measures for the relief of the condition must be applied here as in the catarrhal inflammation. If the fever continue, however, if the ear drum is swollen, red, and bulging, then incision of the drum must be seriously considered. This little operation, however, I feel should always be done by one skilled in such procedures, and a specialist should be called in. If the drum is already ruptured, the canal must be scrupulously cleaned by gently spraying with a warm bichlorid solution 1:4000, or a formalin solution 1 : 5000. Insufflation, after a few days, of fine boric acid and packing the entire canal with this powder will frequently eventuate in a complete healing of the entire process; but just as one should have the assistance of a specialist in the condition demanding an incision of the drum, so one should certainly have his assistance if the case drags on for several days or weeks with an increasing or stationary purulent discharge. Such conditions constantly eventuate in general sepsis, brain abscess, and death.

A cause which is very frequently at the bottom of attacks of otitis media is adenoid growth in the pharynx. This probable cause must never be overlooked, and it should be corrected by removal at the earliest possible moment. Repeated attacks of otitis media may give rise to irremediable impairment of hearing which increases with age. Just here it is well to take into consideration the fact that many cases of "running" ears are considered by the general practitioner to be due to "teething." Every child which is normal must cut teeth, and has consequently "teething"; but the running ear which occurs at this time is not due to the act of teething, *per se;* it is a coincidence, not a result. If the nasopharynx were examined, it would be found that there was inflammation of the mucous membrane or inflamed adenoids. This is the cause of the otitis media; the teething is not. It is true that certain children do have bronchitis, fever, even convulsions, at the time of teething. I know that in some instances the relief of a sore gum is followed by the relief of a train of symptoms from which the child suffered, but I am sure that in the vast majority of instances the teething is only one of the factors in the set of symptoms; it is very rarely the cause, except that sometimes it acts as the disturbing element which unsettles the general vitality of the patient. "The sooner teething is banished from our vernacular, the better for children."

TOOTHACHE

Toothache of a truth belongs to the dental profession; however, the hard-worked country doctor will often find himself in charge of a case of toothache which demands immediate relief. Of course, immediate relief can be obtained by drawing the offending tooth, but this radical method should not be resorted to in these days of scientific dentistry, except as a last resort. The tender tooth can usually be discovered by a careful examination of the mouth and lightly tapping the teeth with some light metal instrument. When the tooth which

is painful is touched with the piece of metal, it will give severe and unmistakable pain to the sufferer. Then usually a cavity can be discovered somewhere about the crown or at the junction of the crown and the root of the tooth. This cavity should be carefully cleared out with a metal instrument—a dentist's forceps not being at hand, the sharp end of a probe or an ear-scoop or eye spud may be used. The cavity being cleaned, it should be dried with a small bit of cotton wrapped on a probe. Another small bit of cotton not as large as the cavity in the tooth should be saturated with creasote or oil of cloves, or a crystal of cocain in the creasote, and placed immediately in the dry cavity. Over this should be gently placed a dry, small piece of cotton, entirely filling the cavity. Occasionally filling the mouth with ice-water will temporarily relieve the pain, and it may even abate the inflammatory attack. If the tooth is dead and there is no cavity, the pain may be temporarily relieved by painting the gum with a mixture of equal parts of tincture of iodin and tincture of opium. This failing, and the tooth still giving extreme pain, if no dental surgeon can be reached who may promptly relieve the pain by drilling the tooth, drawing the tooth is justifiable, it being always remembered, however, that today dentists can permanently save a patient's teeth which a short time ago would have been sacrificed. Injection of cocain into the gum is not justifiable because of the danger of bringing on a septic condition of the gum, and, indeed, a possible cocain habit.

HEMORRHAGE

Doubtless the hemorrhage which is caused by the disease of the various organs will be considered under headings relating to those organs. But it seems proper that hemorrhage as such should be considered abstractly. It must be remembered that hemorrhage is of two sorts—massive, that due to rupture of a blood-vessel, either internal or external, by violence or by disease, and that due to a long-continued leak from an abraded surface, lesion of the mucous membrane, etc., as in the kidneys, intestine, uterus, etc.

It is the massive hemorrhage that alarms the laity at first, and to which the physician attending is at once called. It is the control of the bleeding which is demanded by the patient and his friends, and which, indeed, is often a dire necessity.

The small, inconspicuous hemorrhage from the intestine and uterus, such as the bleeding from the hook-worm disease or gastric ulcer, myomas of the uterus, etc., is, indeed, not often known to the patient. He or she applies for relief of weakness, paleness, dyspnea, palpitation of the heart, etc. The recognition of this hemorrhage and its control by the proper means are the *sine qua non* of treatment.

Massive Hemorrhage.—Bleeding from an artery, caused by rupture of its coat or other violence. The reader need scarcely be told that securing the bleeding vessel and tying it is the proper and final

method of control of the hemorrhage. The means to do this, however, are not always at hand. Emergency control must then be used.

Of prime necessity is cleanliness before the wound is touched. In order that this necessity may be carried out, one must, under certain circumstances, control the hemorrhage without first touching the wound. If the wound itself is badly infected by dirty hands, such as are sure to be present in a mill, in many accidents on steam roads, automobiles, etc., it will avail the patient little to have his life saved on the instant, it may be from hemorrhage, to be sacrificed later to infection.

Therefore, if the hands are not reasonably clean, the bleeding must be controlled by pressure between the bleeding point and the heart, by means of pressure over the main artery, preferably by a tourniquet. This pressure, however, by the tourniquet must be relieved as soon as possible, and the sooner the better; pressure may be applied over the bleeding point itself, by direct pressure with a sterile pad, or by tying the artery, the hands of the operator first being sterilized. Sterile pads may be usually had soon by boiling any clean fabric that comes to hand; and pressure by using them had better be applied, as soon as possible, in the wound itself. Travelers should be instructed to carry with them emergency first-aid dressings, now put up in convenient form, and, indeed, it would be well for practising physicians to supply themselves with these same dressings and carry them in their kit. The proper means of final control of the hemorrhage, except in rare instances, can best be obtained in some hospital ward, or by a physician fully prepared. It needs no description here. If, however, the bleeding is due to a rupture of an artery anywhere where a tourniquet cannot be used, pressure must be made at once in the seat of rupture; one will have to take the risk of infection. Here there will be no wisdom in allowing the patient to succumb to a hemorrhage because of the fear of a possible infection. The bleeding which comes from a ruptured vein in an extremity can always be recognized by the fact that the blood wells up from the wound in a steady flow, and is not ejected in spurts, as is the case when an artery is wounded. Here the mere elevation of the leg or arm will frequently control the bleeding. If it does not, pressure must be made, leaving the wound between the tourniquet and the heart; or better, direct pressure may be made over the wound.

Nasal hemorrhage is usually controlled by placing the patient in a recumbent position, with the head slightly raised. Sometimes light plugging of the anterior nares is necessary. Never allow a patient to sit over a basin of water with his head forward, industriously washing away forming clots. This appears to be the one way the laity understand. Of course, it encourages bleeding. Our patients must be better instructed. In rarer instances the nares must be formally packed. This is usually well accomplished and the bleeding successfully controlled by the use of a simple strip of gauze about one inch wide. This is gently forced back to the posterior nares by means of

a probe, and then packed gently back, each time about one inch of the gauze being used. I have but once in a long experience been forced to call in the aid of a surgeon to pack the posterior nares. This procedure failed then because of a state of hemophilia existing in the patient. The posterior nares, however, may be packed by using a simple catheter. A silk thread is first passed through the catheter, and allowed to extend well beyond its end. The catheter is then passed through the nares, caught with forceps as it comes into view in the pharynx, and drawn forward through the mouth. The silk is held and the catheter withdrawn. A plug of gauze the size of the posterior nares is tied to the string and then drawn through the mouth, inserted by the aid of the finger into the superior pharynx, and drawn into place in the posterior nares.

Bleeding from the seat of a recently extracted tooth may give trouble. Here the bleeding cavity must be thoroughly cleared of clot, a bit of cotton, either plain or soaked in adrenalin solution, is firmly pressed into the cavity, and held there, if necessary, by a superimposed pad, which is pressed hard against the cotton by bringing the teeth together, and binding them there, if necessary, by means of a bandage.

Hemorrhage from the Lungs.—This symptom, which in the vast majority of cases means tuberculosis of the lungs, is rarely immediately fatal, though it may be. The patient may be put to bed, at rest, reassured, and given ice to sip. Frequently these means are all that is necessary. If the cough is severe, or the excitement of the patient great, a hypodermic injection of $\frac{1}{4}$ or $\frac{1}{8}$ grain of morphin should be administered. If the spot of bleeding can be diagnosed, an ice-bag should be applied over the spot. Drugs, beyond the opiates, are of little use, except to satisfy the patient. Indeed, this latter is of no small moment. Nitroglycerin in $\frac{1}{100}$ grain doses may be given every hour, hypodermically or by the mouth. Ergot, gallic acid, and aromatic sulphuric acid are usually useless. The first of these, ergot, is harmful. In the rather massive hemorrhages due to tuberculosis of the lungs morphin must be used hypodermically; at the same time caution must be exercised. I have seen more than one patient in the last stages of consumption so badly narcotized by the use of morphin to control hemorrhage that their lives were despaired of, and in one instance the patient died, because of injudicious use of the morphin, and not on account of the hemorrhage. Occasionally massive or slight hemorrhages occur from the lungs when the cause is not tuberculosis.

An aneurysm may rupture into the trachea or bronchi or lung itself. The first symptom may be spitting of a mouthful of blood at intervals. At first the blood is mixed with mucus, gradually becoming clearer. Then usually there is a furious flow of blood, and life is ended. Frequently, the gush of blood is the first and last symptom, life being extinguished almost immediately. In these latter cases there is no treatment. The case is necessarily fatal. In the cases, however, in

which there is the premonitory bleeding of small quantities of blood, the patient should be absolutely quiet and *no stimulation* given. In rare cases the patient may temporarily recover. I have seen one case with all the physical signs of aneurysm completely recover, so far as the bleeding was concerned. There was no postmortem, but it is likely that in this case there was not a true rupture, but a local congestion somewhere along the line of pressure. Bleeding from a severe pulmonary congestion due to cardiac dilatation may be in large quantities and cause syncope, the syncope apparently saving the life of the patient. Usually, however, the bleeding is characterized by a mixture of frothy blood and mucus. Rest is the necessity in these cases. Rest will soothe the heart and reduce the pulmonary congestion. Ice over the heart is of value. Heart stimulants, such as digitalis, must be used with caution, for fear that overstimulation takes place. Morphin, $\frac{1}{8}$ grain, and atropin, $\frac{1}{150}$ grain, hypodermically are of the utmost value and should be used.

Vomiting of Blood.—Vomiting of blood may be due to a simple ulcer or to a carcinomatous ulceration of the stomach, to rupture of esophageal varix, to duodenal ulcer, or, again, may be secondary to a failing heart. The treatment in these cases is rest; ice to the stomach and morphin hypodermically. The administration of styptics by the mouth is usually harmful. They cause vomiting by irritating the already supersensitive stomach, and thereby do more harm than good. Granting that their local action will cause clotting of the blood, a severe vomiting attack would of necessity dislodge the clot and cause renewed bleeding.

Continued bleeding from an old ulcer of the stomach is sometimes the result of a thrombus being small, and partially obliterating the opening in the bleeding vessel. This incomplete occlusion is maintained sometimes by distention of the stomach by blood. It has been suggested that lavage under these circumstances is not only desirable, but that it is demanded. I would respectfully suggest that while lavage in rare instances might, by removing the blood in the stomach, allow the walls to contract and thereby close the bleeding vessel, its general use is not to be recommended.

An eroded artery in a hard cicatricial wall of an old ulcer will not contract. When one is sure of the diagnosis, far better to open the abdomen and close the bleeding point efficiently. I once saw a man bleed to death from a duodenal ulcer. At postmortem the bleeding point could be seen in the center of the ulcer. Surgical interference would have saved the patient's life.

Bleeding from the rectum may be due to hemorrhoids, polyps, ulceration of the intestinal tract due to carcinoma or to duodenal or simple ulcer, or, in rare instances, the first symptom of typhoid fever to attract attention. The treatment must, of course, depend upon the diagnosis. Hemorrhoids are easily controlled locally, sometimes by application of cold and locking up the bowel, but the hemorrhages of any size which come from further up must be

treated on exactly the same lines as though the blood came from the mouth.

Hemophilia.—Hemophilia is a relatively rare condition, due to some constitutional fault. Here, local means, whether surgical or otherwise, are often of little avail. The patient must be given large doses of calcium lactate. The treatment by the injection of human blood-serum, lately suggested by Welch, promises to be of the greatest value. It is certainly harmless, and in the cases reported has been apparently of great value. The blood is drawn from the vein in the arm, under strict antiseptic precautions. The arm is cleansed. A sterile needle is inserted into a vein at the bend of the elbow, and the blood conducted into a sterile sealed flask. Here it is allowed to clot, and the supernatant serum is taken into a sterile syringe and injected under the skin.

The control of microscopic or macroscopic, but small and continued, hemorrhage is not as dramatic as the stopping of a large flow of blood, but is just as necessary to the life of the patient. Frequently, the control of this class of bleeding is most difficult. The diagnosis of the condition must be made by the physician himself. When a patient is pale and anemic, the first duty of the physician is to get a history, make a physical examination, and examine the blood.

If the blood shows a uniform reduction of hemoglobin and red cells, with leukocytes, without any change in either red or white cells, there is good reason to believe that a hemorrhage is taking place. Examination of the vaginal canal or discharge, or a close inquiry as to the history of this, will possibly reveal an unsuspected hemorrhage. If an eosinophilia is present, one may confidently expect to find an intestinal parasite, especially an uncinaria. Examination of the stools may reveal the ova of this or some other parasite. Examination of the stools for occult blood may fix the hemorrhage as the cause of the anemia, coming either from simple or carcinomatous ulcer. The treatment of these various conditions is obvious, hemorrhage being merely one of the symptoms. As indicated in the paragraph on fainting, it must be remembered that nature occasionally attempts to control hemorrhage by syncope. Unless life is literally threatened, stimulation should be cautiously used.

One of the best methods of increasing the force of the circulation is the introduction of normal salt solution into the vessels. This may be done either by means of enteroclysis, hypodermoclysis, or the solution may be thrown directly into the vein.

INDIGESTION

Like many other, indeed like all other, symptoms, this of indigestion may mean little or nothing—except discomfort. On the other hand, it may be significant of the most serious condition. When a patient suffers from distress after eating, belching, eructation, nausea, or vomiting, much will depend upon the care taken by the physician

whether the individual is to become a confirmed dyspeptic or whether care will cure the condition. Again, these symptoms are often the first to be noted in cases which eventuate in malignancy and the death of the patient; or they may be the result of displaced organs or it may be gall-stones or appendicitis to which all the discomfort is due. Or, again, and closely resembling malignant cases, these symptoms, together with loss of weight, may be due to advancing arteriosclerosis and have nothing in common with malignancy.

No symptom or set of symptoms is more common than the above in the mill hands found in all our industrial centers. These individuals are tainted with the hurry of Americanism and do not take the necessary care to avoid any disturbance of digestion. In some districts work begins at 6.30 A. M., continuing uninterruptedly until 12 noon. Three-fourths of an hour is taken to eat a lunch, and work continues until 5.30 or 6 o'clock. The work is often in rooms filled with dirt and ill ventilated. The evening meal is hurried through, and the individual spends the evening in a room talking or in a theater where the ventilation leaves much to be desired. He retires at 10.30 or 11 o'clock, rarely before the former hour and often after the latter, to begin again the round of work in the early morning. There is no intermission to this routine except Saturday afternoon and Sunday. When one considers the youthful age at which work in the mills is begun, the rapidity with which meals are dispatched, and the amount of pastry, sweets, and fried materials that are used, the wonder is not that mill workers have indigestion but that they can digest anything at all. The only remedy worth consideration is regulation of the life of the patient. He should retire no later than 10 and arise and be ready for his meal at 6 o'clock. Then the universal habit of frying the food almost to a crisp should be supplanted by reasonable methods of cooking. The noon meal should be eaten slowly, with the pies and cakes left out, instead of being hurried through, and the major portion of the forty-five minutes spent in play. If possible, the meal should be eaten in fresh air. I believe it is not Utopian, and it would be actually economical, for mill operators to set aside a well ventilated room wherein the operatives can lunch with comfort in the fresh air. Means for heating the food could be supplied at little cost and would give much comfort to the employees. When one considers the lost time, the listless manner in which many of the hands are forced to go about their work, and that much of this lost time and listless work could be overcome with care, surely it would be economy on the part of mill owners to institute the reforms. To speak of drugs in the treatment of this form of indigestion is almost sacrilege; nevertheless, many of these individuals are forced to work, and to work in the manner described here. Fresh air and rest are impracticable. The best that can be done is to get them to bed early, have them eat properly, and keep as much fresh air in the workrooms as practicable. Every individual can supply himself with fresh air at night if he will. It is part of our duties as physicians to see that the windows of the sleep-

ing-rooms of all our patients be wide open all night. Let the individual keep warm by using sufficient clothing.

Then drugs, a general tonic, such as nux vomica, beginning with fifteen drops three times a day before meals, and increasing one drop daily until twenty-five or thirty drops are taken t. i. d., or the two may be combined with acid or pepsin. If there is much flatulence or heartburn, then the familiar nux and soda. Ten drops of nux vomica, five grains of bicarbonate of soda, in two drams of infusion of gentian, may be used with the greatest benefit. Many of these individuals, especially the girls, while they complain chiefly of indigestion, as a fact are extremely anemic. I think that the anemia should always be measured, however, and not guessed at. In these days of the universal knowledge of the value of hemoglobin instruments and the low price of one of the instruments, Tallquist, there is no excuse for guessing. A mere prick of the needle will show whether the blood contains 50 per cent., 90 per cent., or some other amount of hemoglobin. To use iron when the blood contains 90 per cent. of hemoglobin is useless and harmful; to fail to use it when there is 50 per cent. is just as careless. The form of iron administered is important in these cases of anemia as the result of the overwork and confinement of which indigestion is the main symptom. I have found that Blaud's pill in five-grain doses after meals is well borne and rapidly increases the tone of the whole system, and it brings up the hemoglobin count as well. Care should be taken not to prescribe simply Blaud's pill. If this is done, the machine-made pills, "coated" and as hard as a bullet, are dispensed. They are valueless. Either a formula should be written such as the following:

℞. Ferri sulphatis exsiccati
Potassii bicarbonatis .... āā ʒj
M. ft. cap. xxiv.
Sig.—One t. i. d.

or one of the capsules now on the market filled with the powdered Blaud's pills should be used. The latter perhaps is the best means of using the iron. Indeed, it is better to have the prescription which has been given administered in the powdered form in capsules.

There are individuals who have been drugged by the entire pharmacopeia—by physicians learned and ignorant—none the better off so far as indigestion is concerned because the physician has not taken the trouble to make a physical examination. If such an examination had been made and if gastroptosis or faulty general enteroptosis is present, a well-fitting belt will often cure the entire set of symptoms, and the patient become a reasonable citizen instead of a confirmed hypochondriac. Cases of arteriosclerosis with chronic gastric catarrh and consequent severe gastric symptoms are, as stated above, often mistaken for cases of malignancy. This can best be remedied by first a careful general physical diagnosis, when the arteriosclerosis will be evident, and by examination of the stomach contents and

the position and size of the stomach. Usually the stomach contents are much under the normal in acidity and often the free HCl is entirely absent. However, lactic acid is never present and the Boas bacillus cannot be demonstrated. Often there is some dilatation of the stomach, but there is never any tumor found. Such cases respond best to rest and strychnin. If the arteriosclerosis is the result of alcoholism, alcohol should be stopped. If syphilis is suspected, then mercury hypodermically should be used. Often nitroglycerin given in full doses will give much relief. In cases where the diagnosis is carcinoma, palliative measures must of course be employed. I believe, however, that surgery of the stomach is now so advanced that an exploratory laparotomy is justifiable and mandatory with the hope of giving relief, either by extirpation of the growth or by gastro-enterostomy. Early diagnosis, the avoidance of treating such cases as mere indigestion until entirely irremediable conditions are present, is the one necessary thought to keep in mind.

HEARTBURN

Heartburn being the direct result of either hyperacidity or hypoacidity, the error which causes this symptom must be sought and corrected. If the trouble is in too rapid eating, then the food should be chewed well and swallowed slowly after the chewing, not gulped down. If the amount of food is excessive, then less gormandizing must be practised. If the cooking is deficient, then foods not smothered in fats or disguised with large amount of relishes, but plainly broiled, stewed, or roasted, must be used.

Violent exercise immediately after eating, as well as great mental excitement, should be avoided. For the immediate relief of this most annoying symptom often a drink of water, either hot or cold, will provide the remedy. This, however, will not suffice for the symptom when it is the result of the more or less chronic condition of the gastric mucosa. When this is the fact, and especially when there is hyperacidity, large doses—one-half or a whole teaspoonful of bicarbonate of soda dissolved in water—will often give immediate relief.

If the symptom is a complication of gastric ulcer, which is rare, then proper diagnosis and treatment of this condition are demanded. The reader must remember that heartburn is but a symptom; its relief, therefore, must be only a forerunner of proper diagnosis and subsequent treatment of the underlying condition—the real disease.

BILIOUS ATTACKS

This too familiar failure of diagnosis is mentioned here in the hope that physicians who are in the habit of using the name as a cloak for a failure at diagnosis may be led to look for gastric ulcer, gall-stones, cholecystitis, carcinoma of the stomach, acute indigestion, appendicular colic, chronic appendicitis, gastritis, migraine, hepatic congestion,

gastric crisis of tabes. Here again the reader is referred to the proper section, and urged to drop the term biliousness from his thoughts and vocabulary, or, at least, to limit it to those cases of hepatic congestion due to various causes.

NERVOUS ATTACKS

This cognomen also covers a multitude of sins. Usually the subject of "nervous attacks" is a hysteric woman, sometimes a spoiled child or a malingering adult, occasionally the victim of some organic lesion who is made nervous from fear of the disease, or hysteric when aware an attack of his ailment is about to occur.

Occasionally the hysteric attacks are the first manifestation of a brain tumor. The first duty of a physician called to a patient who has a "nervous attack" is to make a careful examination. If an organic lesion of any organ be found, then measures should be taken at once to relieve the symptoms feared by the patient. The patient should be reassured and calmed by the tactful behavior and language of the physician. Much relief will come simply from the presence of a calm doctor under such circumstances, especially when the doctor shows by his examination that he knows his business. Even true hysteric and malingering attacks will sometimes cease after the examination.

We must all remember that while we do not know the true nature of hysteric attacks, the symptoms are very real to the sufferer; therefore, while the patient and family may be confidently assured that the attacks are not dangerous, they should never be treated flippantly or lightly. The patient must be reassured, and a mild sedative, such as bromid, administered. Bromid of soda or bromid of ammonia in 30-grain doses every one or two hours will frequently give instant real relief.

If the patient is a malingerer, bromid will also be of value, but the firm and unmistakable talk of the doctor will be still more valuable. Morphin should be used in only exceptional cases, for while it will give almost instant relief, there is great danger of the patient acquiring a drug habit, and the remedy will prove a boomerang, and the patient become a real invalid. The general health of the patient must be attended to between the attacks. She must be encouraged to live out-of-doors, to eat nourishing food, to take appropriate exercise, and above all, become interested in some pursuit which will help to make her less introspective, hence less liable to attacks. A most valuable combination of drugs is strychnin and valerianates made up into fresh capsules:

℞. Strychninæ sulphatis............................gr. $\frac{1}{60}$
Quininæ valeratis
Zinci valeratis.............................āā gr. ss

Much more benefit will come from a freshly made capsule than from

the use of a ready-made coated pill, not only because the drugs will be absorbed more quickly and certainly, but because one can vary the proportion of the various ingredients at will.

A malingerer must be taken in hand at a private interview and made to understand that the physician is aware that the symptoms are voluntary manifestations of a bad temper or other peculiarity of the individual. This procedure on the part of the doctor may possibly cause his dismissal, but this will rarely occur if the physician is tactful, firm, and honest.

FAINTING

Fainting, being due to cerebral anemia, is caused by any factor which lessens the amount of blood or the nutritive quality of the blood circulating in the cerebral vessels—hemorrhage, failure of the power of the heart, sight of blood, sudden joy or fear, etc. The final treatment of the attack of syncope must of necessity depend upon the cause, in order that the attack may not be repeated and lead to a serious or perhaps fatal termination.

The treatment of the attack itself, however, is practically the same, whatever the cause. It is a curious fact that the laity have almost without exception the idea that a fainting individual should be set upright. This is, of course, exactly the opposite of the correct action. A fainting individual should be placed in a reclining position with the head somewhat low. All clothing should be loosened. Usually these simple measures are all that is necessary.

If there chance to be convulsive movements in the syncope, these movements need disturb neither physician nor bystander. They are usually extremely slight and without consequence. If the patient remain unconscious for a considerable time and the heart becomes irregular and more feeble, inhalation of the fumes of ammonia, either from the common smelling-salts or from aqua ammonia itself, can be used. If this still does not resuscitate the individual, a hypodermic of strychnin and atropin—$\frac{1}{30}$ grain of strychnin and $\frac{1}{200}$ grain of atropin—may be used.

It must never be forgotten that a faint which is the result of hemorrhage is often conservative. It is a part of nature's method of controlling hemorrhage. The weak heart action and the contraction of the vessels give an opportunity for the formation of a thrombus, which is the only method of control of the hemorrhage where the bleeding point cannot be reached and directly controlled by surgical methods. Therefore, when the cause of the faint is internal hemorrhage, stimulation should not be used except when life is immediately threatened. If the syncope is due, however, to a preëxisting heart lesion, a myocarditis or a dilatation, proper stimulation with camphor, strychnin, or digitalis may be used. Camphor is one of the most valuable diffusible stimulants. It may be used hypodermically in the form of camphorated oil—1 grain of camphor being dissolved in 15 minims of sterile oil.

CONVULSIONS IN CHILDREN

Convulsions in children occur as symptoms of many different causes. They are directly due first to a cerebral anemia, always followed, however, by cerebral hyperemia, congestion, sometimes hemorrhage. This cerebral irritation is more easily brought about in some children than in others, and in some families than in others. A child once affected with convulsions is extremely apt to be affected a second time, and apparently for slighter reasons. Rickets is a very common predisposing cause. Convulsions are extremely common in the beginning of any infectious disease, particularly in scarlet fever, measles, diphtheria, meningitis, whooping-cough and pneumonia.

They are constantly the result of overloading the stomach, either with food unfit for the child to eat, or with food entirely proper in quality, but too great in amount. In this condition the convulsion is probably toxic in origin. This cause is frequently active in whooping-cough. I have seen a number of cases where the attack of whooping-cough itself was not severe, but the child would constantly overeat. The result would be fever, restlessness, convulsions. With the removal of the food from the stomach and bowels the symptoms all disappeared, the patient seemingly none the worse for the unpleasant experience.

Epilepsy as a cause is frequent; the diagnosis can be made only by repeated observations of the cause and the presence of distinct aura and other stigmata.

Actual organic brain disease may result in convulsions. This can be ascertained by the history of the case and by later observations. In certain fatal cases enlarged thymus has been found. Often death is sudden in these cases. Writers attribute both the death and the convulsion to the thymus. I have had no experience with such cases.

Uremia as a cause must never be overlooked; therefore, the urine must be examined at the first opportunity; indeed, it is better if the attack is at all severe or prolonged to make the urine examination for albumin at the bedside. I have seen, in connection with other observers, a convulsion the result of acute nephritis the first symptom of an attack of scarlet fever noticed by the caretakers of the child. Here, as in all other medical conditions, the diagnosis is the *sine qua non* of the treatment, the diagnosis being made only by constant care, history, physical examination, etc. However, the attack or convulsion itself must be treated first in most instances. Frequently, in general practice the convulsion itself is over by the time the doctor reaches the house. It is then the diagnosis is extremely important, in order, if possible, that a second attack may be averted and the real cause intelligently treated. It is only rarely that the doctor is justified in treating the case lightly, with the expression, "Oh! it is only an overloaded stomach," for while convulsions are rarely fatal in healthy children, they may be so in very young infants

or in feeble older children. Hence care should be taken as to diagnosis and after-treatment.

Preventive Treatment.—It has been said that children once affected and children with rickets are liable to recurrence of convulsions. The diet of such children should be carefully watched, care being taken that neither unfit food nor too great quantities be taken. Violent exercise immediately before or after eating should be prohibited; undue excitement, late hours, and other things which unduly excite or exhaust the child should be avoided. If an attack of fever be present, the child should at once be put to bed and the bowels thoroughly evacuated, first by an enema, and then by a brisk purge, citrate of magnesia, castor oil, or calomel. Cases thus treated may frequently avoid what is, at least, an alarming symptom, convulsions.

Treatment of the Attack.—First, quiet the family and parents by assurance and coolness in treatment of the case. The patient should be gently restrained to avoid injury to head or limbs, and in severe cases the handle of a spoon wrapped in a cloth should be inserted between the teeth, to prevent injuring the tongue. The child should be stripped and laid quietly on a couch or bed, the head being rubbed with ice, or kept constantly covered with a cloth wrung out of ice-water. If the latter procedure is undertaken, the cloth must be changed at least every two minutes, otherwise it will become hot instead of cold. The body of the child should be completely wrapped in a cloth wrung out of mustard water (mustard pack of Holt), or the body may be placed in a receptacle containing warm mustard water—a tablespoonful of mustard to two quarts of water. This hot mustard bath is a well-known household remedy, and is usually in effect before ordered by the physician. It is an excellent measure—better, I have thought, than the pack, the trouble being not in the bath, but the hurry, noise, and bustle incident to its use.

The lower bowel should at once be washed out, and a dose of bromid of potassium and chloral administered high, by means of an ordinary soft catheter or by a rectal tube. Ten grains of bromid of potassium and four grains of chloral may thus be administered to a child six months old. While these manœuvers are being prepared for, a few drops of chloroform may be administered to the child by inhalation—a bit of gauze being held about one inch above the mouth and nostril and the chloroform dropped upon it.

The attack being over, the room should be darkened, all except the necessary attendants removed, and the child allowed to rest. If the attack recurs, these same methods should be reëmployed. Occasionally there is a hyperpyrexia, and this should be overcome with a cold pack.

A case observed had been suffering from convulsions for two or three hours, in spite of intelligent treatment. The temperature was found to be 106° F. in the rectum. This child was put in a tub of cold water, the temperature was reduced, and the convulsions ceased, never to return.

If, in spite of these methods, the convulsions should recur, then morphin hypodermically should be used in children six months or over — $\frac{1}{75}$ or $\frac{1}{50}$ grain can be used for a child six months old. Holt advises $\frac{1}{16}$ grain to a well-grown child two years old. This drug will usually control the convulsion. It should not be used in children under six months, however, unless the convulsions cannot be controlled otherwise and they threaten to destroy the child. It must be remembered that repeated continued convulsions may bring about hemorrhage in the brain, which may maim the child for life.

After the attack is over the bowel must again be emptied, the child must be kept on careful diet and in bed. Then careful search must be made for the real cause of the attack, and that cause, whatever it is, be treated.

ENURESIS IN CHILDREN

This annoying symptom is usually the result of an irritable bladder, caused by a child's abnormal nervous condition. Occasionally there is an organic condition, cystitis, or vesical or renal calculus; or there may be a long foreskin in the male, with or without adhesions to the glans. In the female the urethral orifice may be irritated, or there may be adhesions about the clitoris.

The urine should always be examined. If signs of organic conditions of the kidney or bladder exist, such as blood or pus in the urine, or if the urine be highly acid, these conditions must be first relieved, when usually the enuresis will disappear. If the urine is normal, the child should be put to bed without taking any liquid. The foot of the bed should be raised in order that the urine will not reach the neck of the bladder soon. The bladder should be emptied just before retiring. It is a good plan to arouse a child after it has retired and allow it to empty the bladder. If there is an adherent foreskin, which seems a good reason for irritation, this should be relieved either by loosening the foreskin or by circumcision. If there are adhesions about the clitoris, these should be freed, or any extraneous material, such as smegma or the common pin-worm, should be corrected. The best drug known to me is atropin or belladonna, given to the physiologic limit. In addition there should be administered a full dose of bromid, 5 grains to a child a year old, given just before the child retires.

SEASICKNESS; CAR-SICKNESS

Seasickness and its close relation to car-sickness are notable for their resistance to medical treatment. Certain individuals suffer terribly from this distressing condition with a very short trip on the water when it is at all rough, or on taking a train or trolley ride of but a few miles.

An individual intending to take such a trip should see that his bowels are freely moved. The diet in the beginning and during the

trip should be of a light but nutritious character—malted milk, peptonized milk, soft eggs, toast, gruels, plain soups. About two hours before the trip is begun the patient should take 30 to 60 grains of bromid of potassium well diluted; this medication was long ago recommended by Professor Horatio C. Wood, and it has been extremely useful in my hands. During a sea trip the patient should place himself in a semireclining position, preferably on deck, certainly avoiding close apartments with any degree of odor.

Car-sickness can be treated with the bromid just as advised in seasickness; otherwise there is little to do except to make the individual comfortable. In order to obtain comfort, traveling in this country can be done in the parlor-cars—the better ventilation, fewer individuals in the coach, and comfortable chairs are all conducive to freedom from sickness.

CORNS AND BUNIONS

Corns and bunions belong to the chapters on treatment of surgical conditions. They are mentioned here simply because the advice of a general practitioner is so seldom sought, and to warn against allowing a patient to submit himself to the danger of infection from attention of an unskilled chiropodist.

A shoe well fitted to the foot will usually relieve the most painful corn. It must be impressed upon shoemakers that frequently handsome appearance of a shoe must be sacrificed to a shape which will relieve pressure upon a certain toe or point of the foot.

If a toe has become painful on account of unavoidable pressure due to a vicious position of a foot on account of some deformity, it can be relieved by carefully paring the hardest part of the corn flush with the healthy skin. The knife, preferably a broad scalpel or small razor manufactured for the purpose, must be sterile. The part to be trimmed must be made as sterile as possible. Serious degeneration of the entire toe and even limb has occurred from neglect of these precautions, especially if the patient be a diabetic.

After the corn has been carefully shaved, the center may be made soft and the entire corn made less painful by the use of the following ointment:

℞. Acidi salicylici.................................ʒj
Extracti opii...................................℥j
Cerati simplicis..........................q. s. ℥j
M. Sig.—Use locally.

This ointment will soften the center of the corn, thus relieving pressure on the sensitive papillæ beneath.

If the corn is between the toes, this same ointment may be applied to the corn after it has been cleaned and trimmed. The toes should be kept apart by the use of either a bit of cotton or piece of gauze. Particularly useful is the ointment if the corn is on the bottom of the foot. Here there should be applied one of the various perforated corn-

plasters found on the market. Care must be taken that the central opening in the felt is quite large enough. If the opening is small, the pressure over the papillæ will be greater than though no protective were used.

Bunions, being due to a chronic synovitis, usually of the second joint of the great toe, are more intractable and more serious than one simple corn. However, the top of a bunion may be covered with a callus exactly like that of which a corn is composed. Removal of this entails care that one does not open the joint, for frequently the membrane separating the callus from the joint is extremely thin and easily perforated. In this condition a shoe made over a special last is almost a necessity to effect a cure.

No amount of applications can by any means counteract constant pressure from a shoe which is making a prolonged adduction of the toe. If the bunion becomes acutely inflamed, cleansing of the foot, together with application of a saturated solution of magnesium sulphate, will relieve the condition. This entails, of course, complete rest of the patient.

WARTS

Warts rarely give rise to more serious symptoms than annoyance from their appearance. Occasionally, however, when the wart is in a position where it is constantly irritated, it becomes so much inflamed that it demands treatment on that score. Here protection from irritation, removal of the wart by the knife, the application of a saturated magnesium sulphate solution, will suffice.

It is notoriously the fact that warts frequently disappear without the knowledge of the patient and without treatment; this, however, is uncertain, and an individual requesting the removal of the annoying little tumors must be accommodated.

The best method known to me is the application of crystals of chromic acid. A few crystals of the acid are allowed to deliquesce, or a rapid solution is accomplished by a simple drop of water. A probe, preferably the sharp end, is moistened in this practically pure acid and the point of the probe is forced into the wart. Care must be taken that but little of the acid is used, otherwise the irritation of the surrounding tissue will be so great that it will become quite painful.

FOOD-INTOXICATION (BROMATOTOXISMUS) AND POISONING BY REPTILES AND INSECTS

By George Blumer, M.D.

The ways in which food may transmit disease are many and varied, and the conditions resulting from food-poisoning may be of the nature of infections or intoxications, or of a combination of the two. Certain specific diseases, such as tuberculosis or trichinosis, may be transmitted in this way, as may certain poisons eaten by animals subsequently used for food, but it is not our purpose to treat of these in this section. We shall consider here only those conditions in which a toxemia is the preponderant factor, though in some of the diseases to be described an element of infection is also present.

Intoxication from food may be due to substances physiologically inherent in the food-stuff itself, or to the presence of bacterial toxins. In certain hypersusceptible individuals foods which are harmless to normal people may give rise to severe symptoms of intoxication, and such cases may properly be considered in this section. Poisoning may also be due to adulterants, preservatives, or coloring-matters introduced into the food for commercial purposes. In the last-named class of cases the poisonous substances are usually well-known drugs, such as formaldehyd or salicylic acid, and these will be considered under a separate heading. It is considered advisable in this section to classify the different forms of poisoning under the special varieties of food which provoke them, rather than under the specific toxins which are their actual cause. Such a classification is deemed best, as some of the toxins concerned in food-poisoning are not accurately known, and more than one toxin may be present in a single food.

INTOXICATION DUE TO FOOD OF ANIMAL ORIGIN

Meat-Poisoning (Kreatoxismus)

Poisoning from meat may result from toxins formed during the life of the animal furnishing the meat, or from substances developing in the meat after the animal has been slaughtered. In the former instance the animal has generally suffered during life from bacterial infection; in the latter there is, as a rule, a history of improper care of the food or the use of imperfect methods in curing. Usually, these two types of meat contamination give rise to essentially different clinical pictures, and are due to essentially different micro-organisms. In the case of meat coming from a diseased animal, organisms belonging to Bacillus paratyphosus group are usually found, while in meat contaminated after death, Bacillus botulinus is more often

present. Scattered instances of other forms of meat infection are reported, but are much less common than those falling into the two groups just mentioned.

Intoxication Due to Meat Infected with Organisms of the Bacillus Paratyphosus Group.—In most instances of paratyphoid meat poisoning the evidence is in favor of the view that the process is an intoxication, but in some of the reported cases the course of the disease has suggested that a true infection may be present. The bacteria which have been isolated in the various outbreaks of this type of food-poisoning have strong family resemblances. They are bacilli with the morphology of the colon-typhoid group, similar to the organism first isolated by Gärtner in 1888, and named by him Bacillus enteritidis. Studies by de Nobele and others have shown that this organism is closely allied to the bacillus of hog cholera and the Bacillus psittacosis.

Schottmüller, Trautmann, and others have worked out the relationships of the bacteria of this group, and place them under the general head of Bacillus paratyphosus. Bacillus paratyphosus has been isolated from septic processes in animals, and this form of meat-poisoning usually results from the use of meat from septic animals. Often there is a history that the meat was condemned, and subsequently put upon the market surreptitiously. Van Ermengem has shown, however, that the meat does not necessarily come from septic animals, for it may be infected with the organism after its removal from the animal body. In such instances there is usually a history of improper care of the food, and outbreaks reported by Jacobson and Liefmann indicate quite strongly that contamination by bacillus carriers is at times very important. Veal, beef, and pork are the meats most frequently implicated in this form of poisoning; horse and goat flesh are less commonly concerned; fish and chicken have rarely served as vehicles. In an outbreak reported by Rolly, beans were infected with this organism. According to Durham, no instance of mutton-poisoning is on record; Bryson, however, has reported cases. The infected meat may be in the form of sausages, meat-pies, pasties, or canned meat. It is very often unchanged in taste and appearance, though it is probably often sold in these composite and highly flavored forms to disguise any gustatory deficiencies. The longer the time which elapses between the killing of the meat and its consumption, the greater is its toxicity. The toxin of the Bacillus paratyphosus is quite resistant to heat, and very often the poisonous meat has been cooked; in some instances cooking is said to have destroyed the toxicity.

The clinical picture in this type of meat-poisoning is dominated by gastro-intestinal symptoms. After a period of incubation of from two to forty-eight hours the patient is seized with giddiness, nausea, vomiting, abdominal cramps, and diarrhea. The vomiting is at times accompanied by epigastric pain, and is usually associated with headache. The diarrhea is usually profuse, and accompanied

by severe abdominal cramps; in some cases Bacillus paratyphosus may be isolated from the stools in almost pure culture. In some cases there is fever, not, as a rule severe, and in most cases a considerable degree of prostration is present. Petechial skin eruptions have occasionally been noted. While this is the usual picture, there are sporadic cases, and at times epidemics, which simulate typhoid fever very closely. This was the case in the meat-poisoning epidemic reported by Wyss in 1880, in which the patients had continued fever, diarrhea, enlarged spleen, and rose spots; in short, the picture of mild typhoid infection.

The essential lesion of the disease is a catarrhal gastro-enteritis, though in the typhoidal group there may be ulcers in the large intestines. The acute form tends toward spontaneous recovery if the toxin is promptly removed. For this reason the cases which recover seldom last longer than a week; mild cases may be well in two or three days; severe ones may hang on for two or three weeks. The general tendency of paratyphoid intoxication is toward recovery, though different epidemics differ greatly in mortality. An analysis of over 400 cases from the literature shows a mortality of only 2.3 per cent., many of the fatal cases being in children or old people. When death occurs, it is due to the action of the toxin on the nervous and circulatory systems, and the usual signs of cardiac insufficiency are present.

Treatment.—Inasmuch as this disease generally results from the consumption of diseased meat, prophylaxis is of the greatest importance. The most important prophylactic necessity is a careful and rigorous meat inspection by trained inspectors who are authorized to deal with condemned meat in such a manner that there is no chance of its being placed upon the market surreptitiously. In this particular form of meat-poisoning the meat is often unchanged in appearance, and inspection of animals before slaughter, or even a bacteriologic examination, might be necessary to determine with certainty that the meat is tainted. In view of the probability of transmission by paratyphoid carriers, strict cleanliness should be demanded of all who handle meat.

Up to the present time no attempt has been made to apply the principles of specific antitoxic therapy to this form of intoxication, nor is the outlook very encouraging. The results of experimental work with Bacillus paratyphosus are conflicting. In van Ermengem's laboratory absolutely no antitoxic power could be developed in the sera of animals immunized against this organism. On the other hand, Durham claims to have been able to protect animals against infection with Bacillus paratyphosus by inoculating them with the sera of immunized animals, or with that of human beings suffering from spontaneous food-poisoning. It seems unlikely that much will be accomplished along these lines until our knowledge of the formation of antibodies in infections with this class of bacteria is much more extensive than it is at present.

In the absence of specific treatment the indications are to get rid of the offending food, with its accompanying bacteria and toxins, to support the patient through the dangerous period of prostration, which is so common in these cases, and to relieve the inflammation of the gastro-intestinal tract. For the purpose of emptying the stomach the instrument par excellence is the stomach-tube, though emetics are at times of value. In practising lavage it is well to remember, as Barker has pointed out, that a single stomach-washing, however thorough, is not sufficient. The toxin appears to be excreted through the gastric mucosa, so that relapses may occur, and it is necessary to wash the stomach at repeated intervals to get the best results. If emetics are used, apomorphin hydrochlorate, administered hypodermically in doses of $\frac{1}{20}$ to $\frac{1}{10}$ grain, is the best. Emetics which are irritating in nature, such as mustard or the subsulphate of mercury, are to be avoided, as they increase the gastro-enteritis; emetics of a depressing character, like tartar emetic, are also contraindicated.

For removing the contaminated food from the intestines purgatives are necessary, although it might be expected that the diarrhea which is characteristic of the disease would get rid of much of the *materies morbi.* Natural purgation must not be depended on to remove the toxic substances, as experience has shown that patients who are thoroughly purged stand a much better chance of recovery than those who are not treated in this way. Drastic purges should, for obvious reasons, be avoided, and good results have been obtained with salines and castor oil. Calomel is of the greatest value, as it possesses both purgative and antiseptic properties. It should be given in large doses —from $7\frac{1}{2}$ to 15 grains to adults, and to children in proportion. In conjunction with purgatives, high intestinal irrigations of normal salt solution may be given. The injections should be administered through a long rectal tube at a temperature of 100° F., and should be retained as long as possible. The Murphy drip will doubtless be of value after severe purgation has ceased. Normal salt solution has the advantage of possessing stimulating as well as evacuating properties. Some writers, particularly the German school, advocate the use of intestinal antiseptics after thorough evacuation of the alimentary canal. Naphthol, salol, betanaphthol, resorcinol, creolin, and lysol have all been advised. Salol and betanaphthol are perhaps the best drugs of this class, the former on account of its insolubility in the stomach, the latter on account of its slow solubility, which gives it opportunity to act throughout the length of the intestines. Salol should be given in 15-grain doses every three hours, and betanaphthol in similar doses. The patient should be carefully watched for the toxic effects of these drugs, especially after the diarrhea has been controlled.

For overcoming the prostration which occurs in most cases of paratyphosus intoxication the usual methods are to be employed. As most of the fatal cases have occurred in children and old people, these should be watched with especial care. The patient should be

kept absolutely at rest in a warm bed, and artificial heat should be applied to the extremities by means of hot-water bags or hot bottles. Stimulants may be given as indicated, in the form of coffee, brandy, or strychnin sulphate subcutaneously. Dieudonné recommends alcohol in some form, stating that it neutralizes the toxin. In severe cases it may be necessary to resort to the subcutaneous infusion of normal salt solution.

The diet should, of course, be restricted; in fact, during the first twenty-four hours of the disease it may be difficult for the patient to retain anything on the stomach. After complete evacuation of the toxins the severe gastro-intestinal symptoms usually subside, and the patient may be allowed a nourishing liquid diet. Milk, albumin-water, meat-juice, and egg-nog may be given at this stage of the disease. As the gastro-intestinal symptoms disappear, full diet may be gradually substituted. The patient should be encouraged to drink freely of water during the illness, as it favors the excretion of the toxins.

Of special symptoms which may require treatment pain must first be mentioned. The abdominal cramps may be very severe. Local applications in the form of the hot-water or ice-bag should be employed, the choice depending on the preferences of the patient. Chloroform in 3-drop doses on cracked ice may be of service. If the pain is very severe and morphin is necessary to quiet it, this drug must be used with great caution. Any interference with the evacuation of the toxins is to be avoided, and large doses of morphin may have this effect. The vomiting and diarrhea are to be aided, rather than repressed, in the early stages of the disease, for the individuals who suffer most from them usually show least evidence of severe intoxication. The diarrhea often disappears after thorough purgation, but if it persists, it is better to control it by diet and large doses of bismuth subnitrate rather than by anodynes.

Intoxication Due to Meat Infected with Bacillus Botulinus (Botulismus).—This form of meat-poisoning is a pure intoxication, comparable to diphtheria and tetanus. The organism which produces the toxin is a large, spore-forming, motile bacillus, which is a strict anaërobe. It was first isolated by van Ermengem in 1895, and was named by him Bacillus botulinus. The organism secretes an intensely powerful toxin, which is destroyed by heating to 100° C., and by means of which the main features of the disease can be reproduced in the lower animals. In botulismus the contamination of the food takes place during the curing process. Large sausages are especially apt to be infected, on account of the fact that the center is often imperfectly cured. Kempner isolated the Bacillus botulinus from the feces of the hog, which suggests that the use of the stomach and intestine of this animal for sausage coverings is far from devoid of danger. Various forms of meat have given rise to botulismus, but blood and liver sausages are especially dangerous. Beef, veal, ham, corned beef, and larded goose have all been implicated in one outbreak or another. In many instances the manner of their infection is not clear, for the

organism is not one which is widely distributed in nature. Bail has shown experimentally that the organism can be transmitted by flies.

The *symptoms* of botulismus appear after an incubation period of from twelve to twenty-four hours, and are mainly due to the selective action of the toxin upon the heart muscle and the cells of the central nervous system. Gastro-intestinal symptoms, in the form of nausea, vomiting, colic, and diarrhea, may or may not precede the more characteristic secretory and nervous disturbances. The latter consist of more or less complete dryness of the mouth, diminished secretion of urine, or even complete anuria, obstinate constipation, and paralyses. The paralyses are especially apt to affect the eye, the throat, and the larynx. The pupils are usually dilated and fixed; accommodation is paralyzed; and diplopia is often present. Ptosis and ophthalmoplegia are also seen. The voice is at first low and husky; later in the disease complete aphonia may be present. Swallowing may be difficult or completely inhibited, partly on account of paralysis of the pharyngeal muscles, partly on account of the lack of mucus in the throat. With these symptoms there are weakness of the heart muscle and intense general prostration. Fever is usually absent; the intellect remains clear, and sensation is unaffected. The general course of this form of intoxication is apt to be tedious in cases which recover; the paralyses may persist for months. When death occurs early in the disease, it is due to paralysis of respiration, or, less frequently, to the effect of the toxin on the heart muscle. Patients dying late in the disease succumb to inanition and marasmus. The mortality has varied greatly in different outbreaks—Lauk states that under modern methods of treatment it ranges from 20 to 40 per cent. Most of the fatalities occur between the second and the tenth days.

Treatment.—In view of the fact that this disease is a pure toxemia in which preformed toxins are absorbed from the alimentary tract, the main objects of treatment are the excretion of the toxin from the stomach and intestines, the neutralization, if possible, of that which has already gained entrance into the circulation, and the support of the patient's strength.

As in all diseases of bacterial origin, it would be easy to formulate prophylactic measures if we knew more of the natural history of the process of contamination. With our present knowledge we are forced to confine our prophylactic measures to a dissemination of the knowledge that under certain conditions food may give rise to Botulismus, and to instructions as to the method of avoiding such conditions. The public should be educated into the avoidance of raw animal food, especially of food which has a rancid, buttery smell, and those who are engaged in the curing of meats by means of the injection of brine should be advised that a solution containing at least 10 per cent. of salt is to be used.

Knowing the essentially toxic nature of botulism, we should expect that an antitoxin would be available. From the experimental stand-

point, this expectation has been abundantly fulfilled. Kempner and Pollack have been able to produce a powerful antitoxin which possesses both protective and curative properties. So far as we know, such an antitoxin has not yet been used on human beings, though it may be obtained from the Institute for Infectious Diseases in Berlin. Judging from the type of the nerve lesions and our experience with the tetanus antitoxin, it would have to be used early to be efficient, and would probably be most efficacious if used subdurally. Unfortunately, antitoxins, as at present prepared, do not keep well, and this fact, together with the relative infrequency of outbreaks of botulism, will probably defer the practicability of antitoxic treatment until we are able to produce more stable antitoxins.

In face of our inability to neutralize the toxin of botulismus our first aim must be to remove it from the alimentary tract as early as possible. For this purpose the means already discussed under Paratyphosus Poisoning are to be employed. Eliminative measures are of value in botulism only in the early stages of the disease, for later nothing is to be gained by lavage, and the most drastic cathartics may fail to act, on account of the paralysis of the intestinal walls. As in paratyphosus poisoning, lavage and non-irritating emetics are to be used for emptying the stomach, while calomel, castor oil, or saline purges, together with intestinal irrigation, should be used for evacuating the bowels. Here again the value of thorough purgation must be insisted upon. Intestinal antiseptics may be used as in enteritidis poisoning, but care must be observed in the administration of such toxic substances as salol and naphthol, as in this form of food-poisoning the intractable constipation may interfere with their free excretion.

The treatment after the evacuation of the toxin is supportive and symptomatic. The patient is to be kept absolutely quiet, and all sudden movements are to be prohibited on account of the danger of sudden paralysis of the heart muscle. The food should be liquid and nutritious, as in paratyphosus poisoning, and should be administered by a stomach-tube or a catheter introduced through the nose if the difficulty in swallowing is at all marked. Feeding by these methods conserves the patient's strength and minimizes the danger of aspiration pneumonia, a complication to be avoided. Infusions of normal salt solution, either per rectum or, if necessary, subcutaneously, are of value, not only on account of their general stimulating effect, but also because they relieve thirst and tend to increase the flow of the secretions. Strychnin sulphate and atropin have been recommended as general stimulants in this condition, and in severe cases digitalis may be necessary as a heart stimulant. Alcoholic stimulants are of benefit in many cases. The general hygiene of the mouth and skin is of importance—the former on account of the danger of aspiration pneumonia, the latter because of the suppression of the skin secretions.

The symptomatic treatment is important, as many of the symptoms are extremely disagreeable to the patient, whose general comfort is dependent on their relief. The dryness of the mouth, which is

often intense, may be relieved by allowing the patient to suck cracked ice, or by means of rectal injections of salt solution. Where the cardiac condition is favorable, the subcutaneous injection of pilocarpin may relieve this distressing symptom, and at the same time increase the secretions in general. Measures directed against the dry mouth also tend to decrease the difficulty in swallowing, which, however, must be overcome by the use of the stomach-tube if at all severe. The intractable constipation of the later stages of the disease must be treated by high enemata, as even croton oil may fail to move the bowels. A general tonic treatment is indicated after the subsidence of the acute symptoms.

The muscular paralyses, especially those of the eye muscles, may need special treatment, as they not uncommonly persist for months. Galvanism is probably the most efficient means for their relief. The muscles should be directly stimulated by a weak current, administered for a few minutes at a time at daily intervals. The anode should be placed on the nape of the neck, and the cathode should be passed backward and forward over the closed lids, or be allowed to rest for not more than half a minute over each affected muscle. A current of one milliampère is strong enough, and the sittings should not last more than four or five minutes. Faradism has also been recommended, and may be applied by means of a small electrode to the conjunctiva directly over the insertion of the paralyzed muscle. The proceeding is somewhat painful, but this can be obviated by cocainization. The only complication of note which occurs in botulismus is bronchopneumonia. It is to be treated in the usual way.

Intoxication Due to Meat Infected with Putrefactive Organisms.—The number of outbreaks of food intoxication in which the ordinary bacteria of putrefaction are concerned is small compared to that in which Bacillus paratyphosus or Bacillus botulinus are implicated. In most of the instances in which putrefactive organisms have been isolated from toxic food either the Bacillus coli communis or the Proteus vulgaris has been the offender. Outbreaks of food poisoning assigned to one or the other of these organisms have been reported by Dineur, Fischer, Johne, and Jeserich and Niemann. The peculiar outbreak of oatmeal poisoning reported by Ohlmacher really belongs with this group of cases. It seems likely that in instances of this form of food-poisoning the virulence of the colon or proteus bacilli is unusually exalted. The outbreaks are all due to meat which was healthy when slaughtered, but which later became contaminated from careless handling.

The *symptoms* are essentially the same as those of paratyphosus poisoning, nausea and vomiting, cramps, and diarrhea being the most prominent ones. The cases seldom last more than a week, and fatalities are very rare.

Treatment.—This class of cases can, of course, be avoided by proper care of the meat after it is purchased. The matter is one of household hygiene. Cleanliness in the care of the ice-box or the

meat-safe is the main prophylactic measure. After the disease is established, the treatment is the same as for paratyphosus toxemia. (See p. 738.)

Fish-Poisoning (Ichthyotoxismus)

Poisoning from Products Inherent in the Tissues of Certain Fishes.—The glands of a variety of fishes contain substances poisonous to man even when the flesh is free from toxicity. In Europe it has long been known that the roe of the barbel (*Cyprinus barbus, Barbus fluviatilis*) is poisonous during the spawning season. In the West Indies and Australia similar effects have been observed from eating the roe of certain varieties of herring and tropical mackerel. Poisoning has occasionally been observed from eating the liver of the swordfish, and the ovaries of the tetraodon group of fishes are intensely toxic. The symptoms produced by this form of fish-poisoning differ according to the kind of fish used, but two main forms of the disease, the gastro-intestinal and the nervous, are to be recognized.

(1) *The Gastro-intestinal Form.*—This form is the one generally described in Europe as barbel cholera. It is also seen in the West Indies and Australia after eating the roe of *Meletta thrissa* or *Meletta venenosa*, of the herring family, or those members of the mackerel family known as the jurel, the chicaro, and the bonito. The exact nature of the poisons in these forms of toxemia is not known, but poisoning occurs after the use of perfectly fresh fish, and is, therefore, not putrefactive. The symptoms appear after an incubation period of about six hours, the most prominent being nausea and vomiting, followed by cramps and diarrhea. There is usually marked prostration, with a weak and rapid pulse. A burning sensation in the throat is said to be very characteristic. Fatal cases are very rare in temperate climates, perhaps more frequent in the tropics, though exact figures are not to hand. Recovery is usually prompt, the patient sometimes being able to resume work the day after the attack.

Treatment.—The prevention of this form of fish-poisoning is mainly a matter of public education. The sale of the varieties of fish above mentioned should be forbidden during the spawning season. There is no known specific for cases of this kind, and the treatment is purely symptomatic. The stomach should be emptied, even if vomiting has been frequent, and for this purpose lavage is best. A dose of castor oil or of a saline purge should be given. If pain is severe, opiates may be given cautiously. Mucilaginous drinks, such as linseed tea, have been recommended for their soothing effect on the alimentary tract. Prostration should be treated in the usual way by hot-water bags or hot-water bottles, salt solution enemata, and, if necessary, strychnin or caffein subcutaneously.

(2) *The Nervous Form.*—This form of poisoning results from eating the internal organs, particularly the ovary, of the tetraodon or globe-fishes. This group of fishes is found off the coast of Japan and the Malay Archipelago. Several poisons have been isolated

from the ovaries; the one best known is fugin, which resembles curare in its action.

The symptoms of this form of poisoning appear a few minutes after the ingestion of the poisonous food. There are giddiness, numbness of the lips, vomiting, and loss of power in the limbs. The voice may be entirely lost, as may the power over the sphincters. The patient is dyspneic and cyanotic, and rapidly passes into a state of collapse. The majority of those attacked succumb, death occurring in from half an hour to two or three hours after the first symptoms.

Treatment.—Preventive treatment, as in the gastro-intestinal form, must take the form of education of the public, and laws preventing the sale of the roe of the poisonous species, especially during the spawning season. The actual treatment of these cases must be very prompt to save life. The stomach should be thoroughly washed out, and the treatment is then the same as for curare poisoning. Artificial respiration should be practised, and inhalations of oxygen are of benefit if available. If the patient survives the early effect of the poison, diuretics and purgatives are in order. Prostration is to be treated in the usual manner.

Poisoning from Bacterial Toxins in Fish.—In the majority of outbreaks of poisoning from contaminated fish the symptoms have closely resembled botulismus. There is an occasional case in the literature where gastro-intestinal disturbances have followed the eating of spoiled fish, presumably as the result of putrefactive changes.

(1) *Botulismus from Toxic Fish.*—The numerous cases of fish-poisoning which have been described are not, as a rule, classed as botulismus. An unprejudiced study of the symptoms of these patients leaves little doubt that the same toxin is at work. Unfortunately, careful bacteriologic examinations of diseased fish for Bacillus botulinus have not yet been made. Most of the reported cases have occurred in Russia as the result of eating salted salmon or sturgeon. The large size of these fishes and the imperfect methods of preservation make contamination easy. Usually only small areas of contamination are scattered through the affected fish, and cooking destroys their infectivity, just as in meat infected with Bacillus botulinus. The symptoms are essentially the same as those described under meat-poisoning from Bacillus botulinus, and the treatment to be followed is likewise the same.

(2) *Putrefactive Fish-poisoning.*—A few cases are described in literature in which gastro-intestinal symptoms followed the eating of spoiled fish. Some cases of tropical fish-poisoning seem to be of this class, as the fish implicated are not poisonous until some hours after they are caught. Addinsell and Stevenson have described cases in England from eating spoiled sardines.

The symptoms and treatment are essentially the same as those of paratyphosus meat-poisoning.

(3) *Mussel Poisoning* (*Mytilotoxismus*).—A peculiar form of toxemia follows the eating of mussels (*Mytilus edulis*) which have been

grown in contaminated water. The same form of toxemia has occasionally been observed after the consumption of the oyster (*Ostrea edulis*) and the cockle (*Cardium edule*). In all instances the symptoms have been produced by shell-fish which had lived in stagnant or sewage-contaminated water. The toxins of shell-fish poisoning vary in different outbreaks, and are probably due to different bacteria.

Three quite sharply differentiated clinical forms of shell-fish toxemia are recognized—the gastro-intestinal, the exanthematous, and the nervous. In the gastro-intestinal form the patient suffers from nausea and vomiting, followed by purging, with cramps and tenesmus. In the exanthemic form there is a sensation of heat in the skin, followed by an intensely itchy, papular or vesicular eruption. Dyspnea and cyanosis may accompany the skin lesion. In the nervous or paralytic form there are gastro-intestinal symptoms, followed by a feeling of constriction in the throat, formication in the extremities, and general weakness and paralysis. There may be paralysis of the esophagus, and in some cases there is retention of urine from paralysis of the bladder. According to Vaughan, the gastro-enteric and exanthematous forms are due to putrefactive poisons, while the paralytic form is due to a special toxin, mytilotoxin, which was first isolated from mussels by Brieger. Accurate figures as to the mortality of this form of fish-poisoning are not obtainable; it is known, however, that the gastro-intestinal form is the least fatal, and the paralytic form the most fatal.

Treatment.—Prophylaxis is of great importance in shell-fish poisoning. Mussels should never be eaten uncooked. Furthermore, the use of contaminated estuaries for fattening and growing shell-fish should be forbidden by law. The popular superstition that shell-fish are poisonous during the summer months, while incorrect, has doubtless prevented many outbreaks of shell-fish poisoning, for it is during these hot months that the greatest opportunities for contamination exist.

Inasmuch as no specific antidotes for the poisons of shell-fish intoxication are known, the treatment is purely symptomatic. The alimentary canal should be thoroughly flushed, preferably by means of the stomach-tube and intestinal irrigation with hot salt solution. Emetics and cathartics may be used, but are not so suitable as mechanical methods, as they tend to increase both the irritation of the alimentary mucosa and the prostration. For the general condition rest in bed, the application of warmth to the extremities, hypodermics of strychnin, or aromatic spirits of ammonia by mouth are to be recommended. Morphin may be given if pain is intense, but always with great caution. Instances have been known in which too large doses of this drug have prevented the excretion of the toxin and led to a fatal issue. It is better to try and tide the patient over the few hours of acute pain with local applications of ice or heat than to use anodynes. The diet in these cases should be liquid until the gastro-intestinal irritation has subsided.

Poisoning from Fish Venom.—It has long been known that certain varieties of fish are capable of inflicting poisonous wounds if carelessly handled or accidentally trodden upon. Of the species *Trachinus*, the *Trachinus draco*, commonly known as the sea-dragon or dragon weever, and the *Trachinus vipera* or lesser weever, are both capable of inflicting poisoned wounds. Among the *Scorpænidæ*, the *Scorpæna scropha* and also the *Scorpæna guttata*, commonly called the sculpin, are poisonous. The *Serranus scriba*, a variety of perch found in the Mediterranean, can likewise inflict poisonous wounds. In all these fish there are hollow spines connecting with a poison gland. A rather different and more local poisoning is inflicted by certain rays, notably *Trygon pastinaca*, the common sting-ray or stingaree. In this fish there is no poison gland, but the wound is inflicted by a sharp, jagged tail.

The symptoms of poisoning by the venom-secreting fishes may be very intense. There are burning and itching at the site of the wound (which is, of course, either on the hand or the foot), followed by intense pain, which often radiates up the limb, with edema about the wound and sometimes of the limb, and later local discoloration and sloughing. The destruction of tissue may be so great that amputation of the hand or foot may be necessary. Wounds on the finger often leave stiff joints. With the local symptoms there are general ones: a feeling of suffocation and pain about the heart, flashes of light before the eyes, delirium, and even convulsions. The signs of prostration are often marked, and there may even be collapse and death. The wound of the sting-ray, while intensely painful, is not, so far as I can ascertain, accompanied by any marked constitutional symptoms.

Treatment.—The treatment of the wounds inflicted by poisonous fish is essentially the same as that for snake-bite. A ligature should be firmly applied between the bite and the heart until the proper local measures have been carried out. The wound should be freely incised and treated with a 1 per cent. solution of potassium permanganate, or a solution of hypochlorite of lime, 1 : 60. The natives of the Mediterranean shores often use bluestone locally, but its value is very doubtful. Longhurst regards iodin applications, in the form of the tincture or the linimentum iodi of the British Pharmacopœia, as of great value. On account of the tendency to sloughing, strict asepsis should be observed.

Besides the local treatment, morphin may be necessary during the period of great pain, and stimulants are necessary to tide the patient over the period of prostration. Absolute rest is strongly advised by Longhurst. Alcoholic stimulation is recommended by some, as the alcohol also causes deadening of the pain. Strychnin or caffein hypodermically are probably more desirable.

Poisoning with Milk and Milk-Products

This form of poisoning may occur after the use of milk (galactotoxismus), ice-cream, or cheese (tyrotoxismus). In most cases of cheese-poisoning, and in some of milk-poisoning, the toxemia is due

to members of the colon group which, as Vaughan has shown, produce a toxic albumose. In the majority of cases of milk- and ice-cream poisoning, and in a few of the cases of cheese-poisoning, the toxin is the substance first isolated from poisonous cheese by Vaughan in 1883, and named by him tyrotoxicon. This poison is probably identical with diazobenzol; it is quite evanescent, and unless the suspected food be examined soon after its formation, it may be missed. The bacteria which elaborate it are not known. When poisoning occurs from contaminated milk or cream, there is usually a history of improper care of the food. The infection of cheese presumably also takes place from improper care of the milk from which it is made.

The *symptoms* of milk-poisoning, whether due to tyrotoxicon or the colon albumose, take the form of gastro-enteric disturbances. There is, as a rule, an incubation period of five or six hours. Then vertigo, nausea, dryness of the throat, and burning sensations in the esophagus and stomach appear. Chilly sensations, or even severe chills, are not uncommon. Following these symptoms vomiting, cramps, and purging occur. There are headache, feeble pulse, and prostration. Numbness and cramps in the feet and lower limbs may be present, and loss of control of the sphincters is occasionally seen. In the worst cases stupor and delirium may be present. In the cases of milk-poisoning due to colon toxins the depressing effect of the poison on the circulatory apparatus is more marked than in cases of tyrotoxicon poisoning. Most cases of poisoning from milk-products recover in a few days; fatal cases are very rare, and complications directly due to the toxemia are practically never seen.

Treatment.—Prophylactic measures are of the greatest importance in restricting this form of food-poisoning. The faulty handling of the milk may occur either at the dairy farm, during the transmission of the milk to the consumer, or at the hands of the consumer. At the dairy farm the matter is one of cleanliness. The cows should be kept scrupulously clean, especially their udders; they should be milked in special stables, where dust is present in minimum quantity, and the milk should be drawn into sterilized pails by milkers who are dressed in clean clothes, and who have thoroughly washed the hands and arms before milking. The after-care of the milk is also important. It should be cooled and aërated in a dry, clean room set apart for this purpose, as soon after milking as possible. The degree of cooling necessary depends on whether the milk is to be shipped to a distance or used near at hand. In the former instance cooling to 45° F. is needed; in the latter it is not necessary to cool below 60° F. In transportation by wagon the milk-cans should be protected by clean wet blankets or canvas; in transportation for long distances by rail ice should, of course, be used. Milk should immediately be placed in an ice-box when received by the consumer, and should be kept in a separate compartment, as it absorbs flavors from other foods very rapidly. The same precautions are necessary in treating milk which is to be used for making cheese. As far as the cheese itself is con-

cerned, any cheese which exudes a watery, opalescent fluid of acid reaction should be regarded with suspicion.

The active treatment of milk-poisoning should be inaugurated by thorough evacuation of the alimentary canal. The stomach should be thoroughly washed out by means of the stomach-tube, emetics being avoided—at any rate in cases with much prostration. The intestines should be irrigated with hot salt solution, and calomel or castor oil may be administered. Stimulants are almost always necessary, as the prostration is often extreme. Rest in bed with heat to the extremities, caffein, or strychnin hypodermically may be used as indicated. As the acute symptoms subside, Tully's powder or bismuth subnitrate may be given. The Tully's powder should be given with caution, as should morphin if it is necessary to control pain. Antacids have been strongly recommended by some writers; they may be conveniently administered as sodium bicarbonate. The vomiting may be controlled by cracked ice after thorough lavage. Pain is best controlled by local applications of heat or cold, as in other forms of food-poisoning. The diet should be liquid until the gastro-enteritis subsides, but milk should be withdrawn until it is certain that the toxin and its accompanying bacteria have been eliminated.

INTOXICATIONS DUE TO FOOD OF VEGETABLE ORIGIN (SITOTOXISMUS)

Intoxications from vegetable food, like intoxications from animal food, may be due to substances physiologically inherent in the vegetable tissue, or to poisons developed in the vegetable tissue as the result of the action of parasites. In the latter instance molds, as a rule, take the place held by bacteria in animal food-poisoning.

Poisoning from Substances Inherent in the Tissues of Certain Vegetables

Poisoning from Members of the Mushroom Family.—In this form of poisoning the toxic fungi have generally been substituted for the non-toxic by mistake, the resemblance of some of the toxic forms to edible mushrooms being very close. There are two important toxins concerned in mushroom-poisoning—muscarin and phallin. In poisoning from *Russula emetica*, a rare condition, the poisonous principles are not all known, though there is evidence that muscarin is present.

Muscarin Poisoning.—This form of poisoning is generally due to the so-called fly mushrooms. The most important mushrooms which contain muscarin are *Amanita muscaria*, *Amanita pantherina*, *Boletus luridus*, and *Boletus satanas*. The active poison, muscarin, is a colorless, syrupy alkaloid, without odor or taste. Another unnamed volatile toxin is present in most of the members of this group, and probably accounts for some of the symptoms of this form of poisoning.

The symptoms of muscarin poisoning usually appear from one-half hour to an hour after the fungus has been eaten. There are at

first irritative gastro-intestinal symptoms, salivation, nausea, vomiting, violent colic, and diarrhea. Later cerebral symptoms appear; the patient seems drunk; there is excitement; and visual hallucinations or diplopia occur. Epileptiform convulsions and trismus are sometimes present. Finally, drowsiness, accompanied by slow and stertorous respirations, comes on. The pulse becomes slow and thread-like; the face and extremities become cold; and death occurs from cardiac paralysis. The prognosis of muscarin poisoning seems fairly good, judging from the few cases on record. The more promptly treatment is instituted, the better the prognosis.

Treatment.—Education is the only prophylactic treatment. It is difficult to see how it is to be brought about unless the gathering of edible fungi be restricted to trained experts. In certain countries where the peasantry depend partly on fungi for food this would certainly be impracticable. When poisoning has occurred, atropin is the physiologic antidote. It should be given hypodermically in doses of $\frac{1}{120}$ to $\frac{1}{60}$ grain, repeated until the physiologic effect is produced. Most observers recommend it unqualifiedly, but von Jaksch cautions against its use if the secretions are suppressed, as happens in some cases. As soon as possible, the alimentary tract should be thoroughly evacuated, preferably by lavage and intestinal irrigation with salt solution. Apomorphin may be given hypodermically, but irritating or depressing emetics should be avoided. Oily cathartics may be used for purgation, but saline cathartics should be avoided, as the water dissolves the muscarin. After thorough lavage of the stomach tannin may be given; one ounce of a 2 per cent. solution may be administered every fifteen minutes until five doses have been given. The heart's action should be sustained by absolute rest in bed, hot applications externally, and cardiac stimulants, as caffein or strychnin hypodermically. When the skin is blanched and the extremities cold, hypodermics of $\frac{1}{60}$ of nitroglycerin may be given. Every effort should be made to tide the patient over the crisis, as the poison is quite rapidly eliminated. The abdominal pain may be severe enough to require small doses of morphin, or an ice-bag to the epigastrium may relieve it. Nourishment in the form of meat-extracts, egg-albumen, and milk should be given in small doses frequently repeated, as soon as the patient is able to retain it.

Amanita-Toxin Poisoning.—The poisonous members of the Amanita family, notably *Amanita phalloides* and *Amanita verna*, contain two poisons, one called by Ford amanita-toxin, and probably the same as an alkaloid described by Kobert in 1900, the other a hemolytic substance which Abel and Ford have demonstrated to be an easily decomposed glucosid.

The symptoms of amanita poisoning appear from nine to fourteen hours after the ingestion of the fungi. The symptoms in part resemble those of Asiatic cholera. There are vomiting, abdominal pain, choleraic diarrhea, and cramps in the legs. In some patients the hemolytic element in the poison is evidenced by hemoglobinuria,

icterus, and red, serous stools. There is no loss of consciousness, as in muscarin poisoning, and when death results, it is from exhaustion, and usually occurs in from four to five days. Seventy-five per cent. of the cases are said to be fatal.

Treatment.—As no physiologic antidote to phallin is known, the treatment is supportive and symptomatic. The alimentary canal should be thoroughly evacuated, as in muscarin poisoning. After this has been done, general supportive measures are in order. Infusions of salt solution subcutaneously have been recommended, and some observers claim good results from bleeding, followed by the intravenous infusion of normal salt solution. Rest in bed, warmth to the extremities, and stimulants, especially strychnin hypodermically, are to be used.

Lathyrismus (Lupinosis).—This form of poisoning is generally grouped with ergotismus and maidismus, but inasmuch as the poison is inherent in the seeds which cause the disease, and not due to the action of molds, we have thought best to consider it here. This intoxication usually results from adulterating ordinary flour by mixing with it flour made from the seeds of the chick-pea or vetch. Essential conditions are that a large proportion of the daily food must have consisted of the poisoned meal, and that the consumption must have lasted at least two or three months. If the husks of the grain are included, the meal is much more poisonous. The disease was probably known to Hippocrates, was wide-spread in Würtemburg in the seventeenth and eighteenth centuries, and of late years has been observed mainly in India. In the Indian epidemics the seeds of *Lathyrus sativus* are the ones which give rise to the poisoning, but, according to Schuchardt, there are ten other varieties of *Lathyrus* which may be implicated. The exact cause of the disease is still problematic, and it is doubtful whether it is due to a poison produced in the peas by fungi or bacteria, or whether the toxin is inherent in the substance of the pea. The latter view seems more probable. There is little to support the view of Cipriani, that is it an infection with a microorganism which normally inhabits the pollen of beans.

The *symptoms* of the disease occur only in those who use the flour unmixed or only slightly mixed with non-poisonous flour. There is a preliminary stage of cramps in the legs with complete recovery if the grain is given up. The onset is sudden. The patient goes to sleep feeling well, and arises the next morning with stiffness, weakness, and trembling in the legs. The weakness and trembling increase, so that in ten days it is difficult for the patient to walk, even with sticks. Both legs are affected—first the calves, later the thighs. Associated with this there is a complete loss of sexual power. The gait is described by Hendley as a paralytic goose-step. There may be cross-legged progression. The feet seem as if weighted, and the walk is dragging. There is no wasting of the muscles, no loss of muscle tonus, and no true tremor. The tendon reflexes are greatly exaggerated. There is no paralysis of the sphincters. The trunk, head, and upper

limbs are unaffected. The mind remains clear. The prognosis is absolutely bad as far as recovery of the use of the limbs is concerned. Fatal cases are rare.

Treatment.—Prophylaxis is of great importance. The disease is common only in times of famine, because the vetch will survive under conditions impossible for wheat, and because the meal is cheap. Education of the natives is important, together with government supply of wheat or wheat flour during famine years. In some countries cultivation of *Lathyrus sativus* is forbidden by law. The natives of India often persist in using the grain after the preliminary leg cramps have appeared.

The disease closely resembles spastic spinal paralysis, and the treatment is the same as for this disease. The chances of complete, or even partial, recovery are practically nil, and treatment is confined to palliative and symptomatic measures. The defective diet should, of course, be withdrawn, and in its place nutritious but easily digested food substituted. If seen in the earliest stages, the patient should be purged. Aside from the diet, the most satisfactory medicinal agents are hydrotherapy and electricity. The latter may be applied in the form of the constant current, with a large electrode (anode) over the spine, and a second one (cathode) moved slowly over the affected limbs. Or the alternating current may be used, the two poles being changed from the spine to the affected limbs alternately. Faradization and galvanization of the nerves and muscles of the paralyzed limbs seem to be of benefit at times. Electric treatment must be carried out daily or every other day for months to be of value. Baths seem to be of value in relieving the spasticity of the muscles. They should be given at first three or four times a week, later daily. Their temperature should not be too warm, about 86° to 90° F., and they should last from ten to fifteen minutes. Internal medication is of little value, except for its general tonic effect. Strychnin is perhaps the best general tonic for this class of cases.

Solanin Poisoning (Potato-Poisoning).—It is questionable whether solanin poisoning bears any relation to the contamination of potatoes with fungi. Solanin is a normal constituent of the green shoots of young potatoes, and one hesitates, therefore, to ascribe its increase to the action of fungi. Nevertheless, G. Meyer has isolated a fungus from old potatoes containing an abnormal amount of solanin, and claims that by inoculating the fungus into other potatoes he was able to increase the solanin in them also. Besides occurring in the fresh potato buds, solanin is found in the green tuber, and also in diseased potatoes. This form of poisoning is apt to occur after a rainy season, and especially if the potatoes have been kept in damp cellars. The cases usually occur the summer following the harvesting of the contaminated potatoes, and may result from eating either green potatoes or old diseased ones. The poison solanin belongs to the saponin group, and from 0.2 to 0.4 gram must be consumed before poisoning occurs. As much as 13.4 per cent. may be present in diseased potatoes.

The *symptoms* of potato-poisoning occur from two to twelve hours after the consumption of the diseased potatoes. A chill or chilly sensations often usher in the illness. There is usually some fever—at times as high as 103° F. Headache is often present and severe in character. In some cases the only gastro-intestinal symptom is nausea, but most cases have vomiting, abdominal cramps, and diarrhea. A scratchy feeling in the throat is not uncommon. Most of the patients are sleepy and more or less indifferent to their surroundings. Icterus, either confined to the conjunctivæ or general, is not uncommon. Physical examination shows little except reddening of the throat and evidences of a catarrh of the upper air-passages. The voice is unchanged, there is no dilatation of the pupils, and the fever disappears by the third day. The urine may contain a trace of albumin during the acute stages; the stools are mushy and free from blood or mucus. In nearly 600 cases recorded by Schmiedeberg there were no fatalities and no complications.

Treatment.—As in other forms of poisoning, the gastro-intestinal canal should be evacuated. Lavage of the stomach, calomel, and intestinal irrigations are the best means to this end. The patient should be kept warm in bed. There is no known specific antidote for solanin, so the treatment is symptomatic. For the headache, which is often quite severe, the ice-cap is to be recommended. Warmth to the abdomen for the relief of the cramps is preferable to the use of anodynes, though laudanum or other opium preparations may be used, if necessary, but with caution. Mucilaginous drinks, such as thick barley-water, may be used to alleviate the intestinal irritation. Cracked ice may relieve the nausea and vomiting, though this usually disappears after the lavage. The diet should be liquid so long as any signs of intestinal irritation persist.

Poisoning from Substances Produced in Vegetables by the Action of Parasites

Ergotismus.—This form of poisoning occurs mainly in certain remote and badly cultivated portions of Spain and Russia. It is due to the contamination of grain, especially of rye, with a fungus known as *Claviceps purpurea.* The fungus develops within the flower of the growing rye and replaces the grain. The compact mycelium of the fungus occurs in the form of fusiform, curved, grain-like bodies, which are larger than rye-grains, and can be easily separated from them by mechanical means. The development of the fungus is favored by a long wet spring followed by a dry summer. As the poorer classes rely mainly upon bread and similar food-stuffs, and as they are often poorly nourished, they are the most often attacked. The actual toxins which give rise to the disease are sphacelotoxin and cornutin. The effects of cornutin are most marked early in an epidemic, as it is a somewhat volatile substance; the symptoms of sphacelotoxin poisoning are present all through an outbreak.

The disease may take an acute or a chronic form, and in either

case vascular or nervous symptoms may predominate according to the preponderance of sphacelotoxin or cornutin in the meal. Acute ergotismus occurs when the meal contains 2 per cent. by weight of ergot of rye. Children and pregnant women are most easily affected, and the first symptoms usually appear five or six days after the poisoned bread is first eaten. Nausea and vomiting, with cramps and diarrhea, are generally present in the early stages. Later there are burning sensations in the epigastrium and extremities. There may be ravenous hunger and thirst. Fever is occasionally present, as is cyanosis. Disturbances in the vasomotor mechanism are common, and appear first as crawling sensations in the hands and feet, paresthesia, and sensations of cold with slight chills. In the severer form headache and giddiness are present, and in the most marked cases there is delirium, stupidity, and even coma. There is also general muscular weakness, with a small, weak pulse. In pregnant women abortion is common. Death is due to cardiac paralysis. Relatively few cases die in the acute stage, but the prognosis is always unfavorable on account of the tendency to recurrences.

Chronic ergotismus often follows some weeks after an acute attack. This form presents two types, the convulsive and the gangrenous, though a mixture of the two is seen at times. In the convulsive form the prodromal stage is marked by general debility, floating specks before the eyes, ringing in the ears, giddiness, and headache. Crawling sensations in the skin are a prominent feature, and itching and burning sensations are also common. As the disease progresses nervous symptoms become more prominent. The patient becomes stupid and somnolent, and the intelligence and special senses become blunted. Then muscular contractions appear especially in the flexors of the fingers and toes and the extensors of the arms and thighs. The contractures are usually bilateral, are often intermittent, and may last from a few minutes to several days during the stage of contraction. In severe cases there may be epileptiform seizures, opisthotonos, and cramps affecting the facial and pharyngeal muscles. Abortion does not usually occur in the chronic form. Psychic symptoms are common in this form of ergotismus, and may mimic various forms of insanity. In some cases maniacal symptoms are present; in others melancholia occurs, and still others may simulate dementia paralytica. The reflexes are lost early in the disease, and many of the characteristic signs of tabes dorsalis may be present. Trophic symptoms are generally present in severe cases, and a general condition of malnutrition is the rule.

In the gangrenous form the cutaneous disturbances and muscular contractures are followed by marked reddening of the skin and gangrene. The latter, which is of the dry variety, affects usually the extremities, especially the fingers and the toes. Whole limbs are at times involved, and the genitalia or patches of the alimentary mucosa may become gangrenous.

The *prognosis* of ergotismus depends upon the extent to which

the disease has progressed before the poisonous food is stopped. In slight cases complete recovery may take place. In the severer forms, 75 per cent. of the cases, according to Tuczek, are more or less seriously disabled. Those who recover from the convulsive form are left with a tendency to headache, insomnia, or serious mental defects. Some suffer from epilepsy; others are permanently demented. In still other cases there are permanent contractures. In the gangrenous form healing may occur, or the patient may die of exhaustion, or more rarely of sepsis.

Treatment.—In the early stages of the acute form the first indication is the evacuation of the alimentary canal. For this purpose calomel or castor oil is to be recommended. Irritating purges are to be avoided. In conjunction with medicinal agents, intestinal irrigation is of benefit. Later in the disease, if the diarrhea persists, it should be controlled by the use of opium. Tannin has been recommended as being a chemical antidote to ergot, but its practical utility is doubtful. Chlorin, in the form of chlorin water, has also been used, but as it is probably transformed into hydrochloric acid before reaching the toxin, its use is of doubtful benefit. Intestinal antiseptics are of value both on account of their effect on the diarrhea, and because they tend to prevent infection through the intestinal tract. Those most highly recommended are salol, betol, and beta-naphthol. Amyl nitrite and the nitrites, while theoretically indicated to counteract the vascular spasm, have practically proved of little value in the acute form. For the prostration the usual remedies, rest in bed, hot applications, strychnin, coffee, and alcoholic stimulants may be used as indicated. The diet should be liquid but nourishing, and solid food should be withheld so long as the gastro-intestinal irritation lasts.

In the chronic form the main indication is to build up the general health. The poisonous bread-stuff should, of course, be withdrawn, and in its place nourishing food, especially meat, eggs, and milk, should be substituted. It is well at first to almost entirely withdraw bread. Thorough purgation should begin the treatment, and should be followed by intestinal sedatives, preferably tannin in some form. Opium may be given if the diarrhea is severe. The nitrites may be used to counteract the vessel spasm, as they seem more efficacious in the chronic than in the acute form.

Aside from these general procedures, the treatment is purely symptomatic. The muscular cramps are best controlled by opium. Chloroform is contraindicated even in severe cramps, as after its use the attacks return with renewed severity. For the epileptiform seizures chloral seems to be more efficacious than the bromids. The cramps in the extremities may be treated locally by means of friction to the affected part or extension and the use of bandages. General warm baths have a good effect on the cramps in many cases. Local applications of the galvanic current may be of service. Severe contractures should be turned over to the orthopedist. For the creeping

sensations in the skin the electric brush may be used. The cardiac weakness needs close watching, and the use of the usual cardiac tonics as indicated. The severe psychic disturbances can be treated satisfactorily only in an institution for mental diseases.

In the gangrenous as in the spastic form the treatment should be initiated by thorough purgation. After this has been done, attention may be turned to the local lesions. A good deal may be done during the stage in which the redness and lividity of the skin indicate approaching gangrene. Local lukewarm baths and the administration of the nitrites are mainly to be relied upon. After gangrene has actually occurred, the cases are to be treated on surgical principles. Operative interference is not called for until a definite line of demarcation has occurred, and the process shows no further tendency to extension. The anemia which accompanies the disease should be treated with the usual ferruginous tonics and small doses of quinin.

Maidismus (Pellagra).—This form of intoxication occurs mainly in certain districts in Italy where maize is the staple article of food. It has recently been recognized, however, that it is not at all infrequent in the United States. According to Kerr, there were probably 5000 pellagrins in this country in 1909. It is due to poisonous substances which develop in the maize as a result of improper care. The poisons, which are due to the action of fungi and possibly also bacteria, occur mainly in maize picked in an unripe condition and stored in moist places. Lombroso has isolated from the spoiled maize two toxic principles, one an alkaloid similar to strychnin, and called pellagrozein, the other a narcotic substance resembling nicotin.

The *symptoms* of this disease affect the gastro-intestinal tract, the nervous system, and the skin. In mild cases, or in the first stage of severe ones, the disease begins with symptoms of gastro-intestinal irritation. There are anorexia, a feeling of heat and pain in the epigastrium, and, as a rule, diarrhea. At the same time there are headache, usually occipital, giddiness, and general weakness with unsteadiness of gait. The individual is irritable, has a general disinclination to work, appears stupid, and often complains of a feeling of pressure in the head. The skin shows a local or general erythema which looks like an indolent erysipelas, and affects especially the exposed parts. These symptoms appear in the early summer and may regress in the fall, but the general history of such cases is that they have a yearly recidive, each attack leaving behind more permanent residua. With the return of the old symptoms the disease becomes more aggravated, and the cerebrospinal symptoms become more prominent. Subjectively, the patient complains of itching and burning of the skin and formication. There are chilly sensations, ringing in the ears, pain in the head, neck, and back, giddiness, and a feeling of bodily and mental incompetence. Objectively, there are motor disturbances in the form of muscular weakness, localized paralysis of muscles or groups of muscles, painful spasms of the muscles, especially on voluntary motion, areas of skin

anesthesia, increased tendon-reflexes, and at times epileptiform seizures. Psychic disturbances become more marked and there may be stuporous melancholia, with a tendency to suicide. There are also vasomotor and trophic disturbances. The skin shows a variety of changes; there may be areas of pallor with cutis anserina, capillary injection of the skin of the face, and edema. The characteristic erythema becomes worse with each successive attack, and leaves residua in the form of pigmented areas of skin, the intervening skin being smooth, dry, thin, atrophic, and inelastic. In some cases the infiltration persists, the skin being livid and fissured. With successive attacks the gastro-intestinal symptoms also become more pronounced. The tongue is often furrowed, cracked, and denuded of epithelium, nutrition is interfered with, and finally the last stage in the disease, the stage of cachexia, is reached. In this stage the patient is bedridden; there are marasmus, atrophy, urinary incontinence, intractable diarrhea, and finally signs of heart failure, edema, ascites, and general anasarca. Death may take place with the signs of broken compensation, or may occur from terminal infection, either in the form of pulmonary tuberculosis or of general sepsis. Occasionally there is a sudden intensification of the pellagra symptoms, the so-called typhus pellagrosus, to which the patient succumbs. The disease is usually a chronic one, and may last ten or even fifteen years without ever reaching its severest grade. In most cases in which recurrent attacks occur the patient either dies or is disabled for life. Recovery hardly ever takes place, except after a single attack or one or two mild seizures.

Treatment.—Prophylaxis is of great importance. It must be partly educational and partly in the form of mandatory laws. Maize should be included among the foods which are inspected by law, and proper officers with power to destroy, as well as to condemn, should be appointed. Physicians, especially those in the large public institutions, should be educated in the recognition of the disease, and should be required to report all cases. The farmers should be instructed in the proper care and storage of their corn.

According to von Jaksch, therapy is almost useless, and at the best can be but symptomatic and palliative when the disease has fully declared itself. There are no specific antagonists to the poisons. Before everything else in importance is the withdrawal of the infected food, and the substitution of wholesome nourishment and plenty of it. As the disease attacks particularly the ignorant and poverty-stricken, this is often impossible. Even when patients are able to avail themselves of hospital treatment they often go home and return, like the dog to his vomit, to the diet of poisoned maize. Symptomatic treatment will often serve to alleviate the sufferings of the victims of this disease. The gastro-intestinal tract should be evacuated, preferably by calomel, after which styptics should be used to control the intestinal symptoms. Bismuth subnitrate, tannin, and opium are of value, and their use may be aided by enteroclysis. Of general

remedies, arsenic seems to have rendered most service. It is best given as Fowler's solution in doses of from 5 to 30 drops daily over a period of two or three months. It is especially serviceable in cases with severe disturbances of nutrition, loss of strength, or beginning paresis, also in very old people. For giddiness the tincture of cocculus orientalis, 10 to 15 drops daily, has been recommended. Warm baths are of use for the general feeling of debility, and cold baths and douches may be used for the localized paralyses and the burning sensations in the skin. For the anemia, iron and small doses of quinin are recommended. For the spinal symptoms ergotin, strychnin, angostura, opium, and chloral have all been used. Electricity is also of value. The psychoses of the disease are best treated in a hospital for the insane, and the more severe and cachectic cases can be satisfactorily handled only in a general hospital.

POISONING FROM PRESERVATIVES OR ADULTERANTS IN FOOD

In recent years there has been a great deal of opposition on the part of medical men to the use of preservatives in food. It has been claimed that these substances are detrimental to health, but more often their use has been opposed on general hygienic grounds. As a matter of fact, a review of the literature shows remarkably few instances in which it can be definitely shown that a given preservative was the cause of disturbances in health. That this should be the case is not to be wondered at, for, obviously, preservatives and adulterants which give rise to acute or striking symptoms are not employed, and in tracing the possible origin of mild gastro-intestinal or renal disorders, we do not perhaps keep sufficiently in mind the possibilities of poisoning from food adulterants. On theoretic and experimental grounds a number of the commonly used preservatives should be condemned, and it does not seem to be going too far to prohibit the use of any substance which might prove detrimental, because those who use preservatives in a commercial way often overlook the fact that a substance that is harmless in small quantities is dangerous in large ones, while at the same time they reason that a substance which preserves well in small quantities will preserve better in larger ones. The danger from these substances to the healthy adult is probably small, but the same cannot be said of the danger to infants or those weakened by disease. The preservatives which have been most extensively used in the past few years are the boron compounds (borax and boric acid), formaldehyd, sodium and calcium sulphite, and salicylic acid.

Poisoning by Boron Compounds (Borismus).—Borax or boric acid is commonly added to milk and milk-products, to opened clams and oysters, to fresh and salted meats, and to sausages and canned meat. The quantity of preservative present in milk is often equivalent to 15 to 30 grains to the quart. In butter, 35 grains per pound is often present, and in cream, 17.5 grains to the pint. Har-

rington has found as much as 4.5 grams of boron compounds in a pint of Norfolk oysters. The majority of American canned meats contain over 1 per cent. of boron compounds, and many samples contain from 3 to 4 per cent. Harrington has estimated that it would be possible for an adult to consume as much as 7 grams of borax at a single meal by using a number of the substances which are ordinarily preserved by its use.

Symptoms of boron poisoning from food have so far been noted only in infants. Tubb, for example, noted an outbreak of diarrhea in infants fed upon borated milk, which ceased when the suspected milk was discontinued, and reappeared on the resumption of it. Allen, of Birmingham, England, has also noted malnutrition in infants fed on borated milk which disappeared when fresh milk was substituted. After the medicinal use of the boron compounds, even after so small a dose as 4 grains of boric acid daily, unpleasant symptoms may appear. Those most commonly noted are nausea, vomiting, diarrhea, psoriatic or eczematous skin eruptions, cutaneous petechial hemorrhages, and albuminuria. The experimental work of Harrington shows that even small doses of boron compounds, if long continued, cause serious kidney lesions. The work of Foulerton, and that of Halliburton, has shown that these compounds inhibit the action of the digestive enzymes.

Treatment.—The most important treatment in this as in all other forms of food-poisoning is prophylaxis. Laws regulating the inspection of food and imposing penalties on the transgressor are on the statute books of most States, but are loosely administered. It is unlikely that they will be rigidly enforced until the public is educated up to their necessity. The responsibility for this education rests largely on the shoulders of the medical profession. The view which we should take has been tersely put by Grünbaum when he says, "We should use 'aseptic' and not 'antiseptic' food."

If suspicion points to boron poisoning in a given case, the first step to be taken is to determine what article of food is contaminated and to discontinue its use. After this has been done the alimentary canal should be thoroughly evacuated by means of calomel or salines. The patient should be placed on a liquid diet until the symptoms of gastro-enteritis have subsided, and if these are severe, large doses of bismuth subnitrate may be given.

Formaldehyd Poisoning.—This substance is used mainly as a milk preservative, and is on the market for this purpose under various trade names. Apparently no case of formaldehyd poisoning from preserved food is on record. The work of Bliss and Novy and that of Foulerton show that this substance, in dilutions as high as 1 : 40,000 has a restrictive action on the digestive ferments, and renders the food less digestible by its direct action. The recent experimental work of Fischer shows that formaldehyd is a dangerous poison, producing local inflammatory lesions, and degenerative changes in the parenchymatous organs. Foulerton thinks it unlikely that the

amount of formaldehyd ordinarily used in food would produce any deleterious effect, but it would tend to make certain foods, especially milk, less digestible.

Poisoning from Sulphites.—Sodium or calcium sulphite is occasionally used as a preservative in sausages and dried fruits. Borntrager has reported the case of an individual in whom the use of such sausages caused headache and a sense of pressure in the epigastrium. Similar symptoms, also nausea and vomiting, have sometimes been noted from the medicinal use of these substances. The treatment of such cases is the same as that for boron poisoning.

Salicylic Acid Poisoning.—Salicylic acid is used as a preservative in fruit-juices, wine, beer, cider, catchup, jams and jellies, and preserved fish. No case of salicylic acid poisoning from food is known, but its use should be forbidden, as fatal cases of poisoning have resulted from very small doses. As little as 0.7 gram has caused death.

Poisoning from Coloring-matters.—Judging from the literature of recent years the poisonous mineral substances which were formerly so extensively used for coloring confectionery, pickles, fruit-syrups, jams, and jellies have been given up. In their place annotto and the anilin dyes have been substituted. According to Abbott, it is unlikely that the amount of anilin used for this purpose is sufficient to produce harmful effects. The use of butter-yellow (dimethylamidoazobenzene) is said to have occasionally caused nausea and vomiting, and should be stopped. There is no reason for the use of coloring-matters other than public demand, and this has probably been fostered by the retailer. Public education should correct this state of affairs and remove the slight danger from poisoning from this source which at present exists.

FOOD-POISONING DUE TO HYPERSUSCEPTIBILITY

There are to be found in medical literature not a few reports which show that marked hypersusceptibility exists in some people to everyday articles of food which are harmless to normal individuals. In infancy such a hypersusceptibility may exist to cow's milk, this substance causing gastro-intestinal symptoms and an urticarial eruption wherever the milk touches the skin. This is, of course, usually about the face, but in Steele's case temporary urticaria could be produced anywhere on the surface of the body by the application of milk.

In another group of patients there is great hypersusceptibility to eggs in any form, and quite severe symptoms may be produced by even minute quantities of the offending food. These usually take the form of gastro-intestinal irritation, vomiting, and diarrhea, with burning of the mouth and throat, swelling of the face and perhaps the fauces, urticarial eruptions, and in very severe cases symptoms of collapse. Similar hypersusceptibility may exist to buckwheat, as in Smith's case, and to a lesser degree to strawberries, tomatoes, and shell-fish.

It seems reasonable to assume that these cases are instances of anaphylaxis, there being a hypersusceptibility to certain substances in the offending food, probably to proteids. A neurotic element is undoubtedly largely present in some of the reported instances of food hypersusceptibility, but will hardly serve to explain the cases which begin in infancy, or, indeed, the marked instances in adults.

Treatment.—There are but few recorded instances in literature where any serious attempt has been made to overcome these food idiosyncrasies. On theoretic grounds, it seems rational to attempt to produce an immunity by giving the patient minute quantities of the offending food and gradually increasing the dosage. This has been done in at least one patient with hypersusceptibility to eggs. In the case reported by Schofield, pills containing $\frac{1}{10000}$ part of an egg were given for a month. During the next month the dose was gradually increased until, at the end of the period, the patient was taking $\frac{1}{1000}$ of an egg. By still further increasing the dose a cure was finally effected after several months. Schofield's patient was also given two grains of calcium lactate three times a day. Herschell treated one patient with egg idiosyncrasy with vegetable charcoal with apparent success. Miller suggests atropin in the severer cases, on the ground that the symptoms resemble those of muscarin poisoning. There seems to be no reason why other forms of food hypersusceptibility may not be successfully handled on these general principles.

Poisoning by Reptiles and Insects

SNAKE-POISONING

Poisonous snakes are distributed, more or less widely, over all portions of the world, New Zealand and most oceanic islands excepted. In temperate climates, especially in highly cultivated countries, their number is limited; in countries like the United States, in which uncultivated areas of land are common, and in which there are semitropical zones, they are more numerous, while in tropical countries, like India, Africa, Australia, and South America, the numbers are large and the species more varied. All the poisonous snakes belong to one or the other of two great groups, which, as a general rule, exert their toxic influence through different poisonous principles acting in dissimilar ways. One group, the colubrines, poisons, in the main, by means of a neurotoxin, while the other, the viperine, produces its most important poisonous effects by means of a hemorrhagin. In the colubrine venom, however, while the neurotoxic element predominates, the hemorrhagic exists to some extent, and, conversely, in the viperines, while the hemorrhagic element predominates, the neurotoxic is also present. The neurotoxic poison exerts a selective action on the cells of the central nervous system, particularly those of the respiratory center; to a less extent it causes lesions in the motor end-plates of the nerves, especially those of the phrenic. The hemorrhagin, on the other hand, causes an intense local reaction in the form

of swelling, this being due to the destruction of the vascular endothelium, with escape of the blood into the tissues; this change is commonly associated with extensive necrosis. The general symptoms of viperine poisoning are due to the neurotoxin, while the local changes in colubrine poisoning are due to the small amount of hemorrhagin which this venom contains. The poison of both colubrines and viperines contains also a hemolysin, but this has not the practical importance of the other two toxins, as it probably plays a relatively insignificant part in causing a fatal issue. There are snakes belonging to each of the great classes whose venom contains almost equal proportions of neurotoxin and hemorrhagin, but they form a minority of the poisonous snakes. The common poisonous snakes of the United States, the rattlesnake (*Crotalus*) in its various forms, the copperhead (*Ancistrodon contortrix*), and the moccasin (*Ancistrodon piscivorus*), belong to the viper family, and poison mainly by means of a hemorrhagin, though the venom of the moccasin contains also a considerable amount of neurotoxin. The colubrine family is represented in the United States by the coral snake (*Elaps fulvius*) of the South, which, though poisonous, is so good-natured or sluggish that it is hardly ever known to bite human beings. In Europe and Africa the adders and vipers are both representatives of the viperine class; in Australia all the poisonous snakes are colubrines, while in India both viperines and colubrines are represented. The Australian snakes, as well as the banded krait (*Bungarus fasciatus*) of India, secrete venom which contains almost equal quantities of neurotoxin and hemorrhagin. The amount of venom necessary to cause a fatal issue in man varies with different snakes, and is hard to determine, as there is no way of accurately telling how much has been injected in a given case. In animals the question has been worked out to some extent. According to Rogers and Fraser and Elliot the Indian sea-snakes (*Enhydrinæ*) secrete the most powerful toxin known. The minimum lethal dose for rats, which are unusually susceptible, is 0.00009 gram per kilo of body weight. This poison, according to Rogers, is, weight for weight, ten times more powerful than cobra poison. Crotalus poison seems much less powerful, as Flexner and Noguchi give 1 milligram as the minimum lethal dose for guinea-pigs weighing from 350 to 400 grams. It must be borne in mind that different animals have different susceptibilities, and these figures may not accurately express the toxicity of these poisons for man.

Symptoms.—The clinical symptoms of snake-poisoning depend on the character of the snake inflicting the injury. The effect of a cobra bite may be taken as an example of poisoning by a typical colubrine. In rare cases the poison may be injected directly into the circulation through the fang entering a vein, and death may then occur in three or four minutes, with general muscular twitchings and convulsions. Usually the poison is injected into the subcutaneous tissue, and, after an incubation period of from one-half to two and one-half hours, the patient begins to complain of lethargy and drowsiness.

Then nausea and vomiting often occur, followed by paresis of the extremities, especially the legs. There may be paralysis of the muscles of the tongue and throat with loss of the power of speech. There is often profuse salivation, with slobbering. As the case progresses, the paralysis becomes more general and more marked, symptoms of respiratory paralysis appear, there may be convulsions, and death occurs from respiratory failure. The local symptoms are not marked, though there is usually swelling, and at times hemorrhagic infiltration in the neighborhood of the wound. Pain may be quite severe, and may follow the course of the nerve supplying the injured area. About 75 per cent. of the cases of cobra poisoning are fatal.

The symptoms of viperine poisoning, as typified by the effect of a rattlesnake-bite, are quite different from those of colubrine poisoning. The local effects are much more prominent. There is usually pain at the site of injury immediately after it is inflicted; then swelling appears, and rapidly spreads to adjacent parts, the pain in the meanwhile increasing. The swelling is associated with discoloration of the affected area from the effusion into it of blood, so that ultimately the swollen zone may look black and blue, like a bruise. In many cases there is extensive sloughing of the swollen area with bacterial infection. The infection may lead to a fatal issue, the subjects of viperine bites being especially liable to sepsis, as the toxin destroys the bactericidal power of the blood. The general symptoms of rattlesnake-poisoning are great prostration with nausea and vomiting, cold sweats, and a feeble pulse. The facial expression is anxious, and in a few cases the mind is disturbed. Patients who die early succumb from the effects of the neurotoxin on the respiratory or circulatory centers, while those who survive these effects and die later succumb to sepsis. The percentage of fatal cases in rattlesnake-poisoning varies between 12 and 20. Copperhead poisoning gives rise to similar symptoms, but is much less fatal; judging from the statements of Carpenter, the mortality must be almost nil, as he claims a knowledge of at least 12 cases which recovered without medical aid.

Treatment.—The objects of treatment in snake-poisoning have been clearly stated by Langmann. They are: (1) To prevent absorption of the poison; (2) to destroy or neutralize it; (3) to accelerate its elimination; (4) to treat symptoms of imminent danger.

To prevent absorption, the surest and best means is the ligature. This means is, of course, applicable only when the bite is on an extremity, and luckily most bites are in this situation. All writers suggest a ligature between the bite and the body, and some suggest multiple ligatures in this situation, or a second ligature distal from the wound. A single ligature proximate to the body is sufficient if efficiently applied. It cannot be efficiently applied to the forearm or lower leg, where the vessels lying between the bones are uninfluenced. For purposes of ligature it will usually be necessary to use available material with an improvised tourniquet, for snake-bites do

not generally occur in centers of civilization. The use of the Esmarch bandage has been highly recommended by the Indian physicians, and this may be applied if available. Caution must be used in removing the ligature, as this will be followed by a sudden flooding of the system with the poison, except in those instances where the poison has caused intravascular thrombosis. For this reason the best authorities direct that the ligature be loosened only a few seconds at a time and then reapplied. In connection with the ligature suction of the wound may be used, but this is seldom of value unless the wound is unusually open, or unless it be preceded by free incision of the injured part. The so-called snake stones, which are merely small rhomboidal pieces of partly calcined bone, act by exerting suction, but this is so slight that they are absolutely valueless. Some of the Indian physicians recommend free excision of the area involved by the bite. In the case of a finger or toe amputation may be of service if performed within two or three minutes of the bite; later than this it is not justified. In all operative procedures the asepsis must be as strict as possible.

To destroy or neutralize the poison local and general procedures are employed. For local application innumerable remedies have been suggested; their very number is an index of their futility. Various caustic substances, including the actual cautery, have been used for this purpose. They are usually contraindicated on account of the tissue destruction which they cause. Of the large number of preparations which have been suggested, a few have retained some shreds of reputation. Permanganate of potash, first recommended by Fayrer, has gone through various stages of popularity and disgrace; its use has recently been revived by the Indian school. Rogers has reported 19 cases treated with it, with recovery in 17. According to Lamb, it should be used in conjunction with free incisions, into which the pure crystals, slightly moistened, should be freely rubbed. Lauder Brunton has devised a small lancet with a hollow handle in which the permanganate is to be carried. The instrument is cheap and convenient, and is meant to be carried by all exposed to the danger of snake-bite. Of other chemicals, 1 per cent. chromic acid solution is said to be of value, and Calmette has recommended a 1 : 60 solution of hypochlorite of lime. Ammonia has also been used, but acts purely as a stimulant, and should not be injected locally, as it causes thrombosis and other undesirable complications.

Of late years our attempts to procure a substance antagonistic to the systemic effects of snake venom have been centered on the production of an antitoxin. The claim made by Calmette, of Lille, that in his antivenin we had an antidote of universal application, raised hope that success in this respect had been won, but the later investigations of Rogers and Lamb in India, of Flexner and Noguchi in this country, and of Martin and Tidswell in Australia have shown that his deductions were not based upon fact, and have demonstrated, as was to be expected, that snake-venoms are so complicated in

composition that no single antitoxin can be expected to neutralize all varieties. Some recent investigators, indeed, hold the view that, notwithstanding the similarity of action of the neurotoxins and hemorrhagins from the different varieties of colubrines and viperines, it will be necessary to produce a special antitoxin for each individual one. Whether or not this assumption is correct, and our experience with bacterial antitoxins favors the view, the fact remains that the antivenin of Calmette is the only form of antitoxin which is at present available for use, or which has been subjected to actual test in human cases. There is good reason to believe that Calmette's antivenin is efficient to a certain degree in the treatment of poisoning from cobra venom. The reported cases in which it has been used in India show, as Lamb justly says, that those who recovered all had mild infections. It is not to be assumed from this, however, that the treatment is a failure. On the contrary, animal experiment has demonstrated its efficiency, and there is little doubt that when it is possible to prepare it in greater strength or administer it in larger doses, it will be successful. The drawbacks to its efficiency as at present prepared are twofold. In the first place, the quantity necessary to neutralize the average dose of cobra venom is enormous, and, in the second place, although it is supposed to be polyvalent, it almost entirely fails to neutralize the hemorrhagin which is present to an appreciable extent even in the venom of colubrines. As Lamb shows, to accurately gage the dose of antivenin we must know the neutralizing power of the serum, the amount of poison usually injected by the species of snake in question, and the maximum non-lethal dose of this particular venom for man. As far as the common cobra is concerned, Lamb demonstrates that after the injection of the maximum amount of venom the quantity of antivenin necessary to cure a human being would be 350 c.c. intravenously, or from 3500 to 10,000 c.c. subcutaneously. As the latter dose is obviously impracticable, he suggests that antivenin be given in doses of from 300 to 400 c.c., and always intravenously. This refers only to cobra poisoning, and in cases of poisoning with other Indian colubrines the dose would have to be greatly increased, as the antivenin is much less specific for their poison than it is for that of the common cobra. Notwithstanding these theoretic objections, we should continue to use antivenin, as we can never tell just how much venom is introduced, and we may inject just enough antibody to keep the dose of venom below the fatality point.

As far as the viperine venoms are concerned, Calmette's antivenin is worthless, and special antitoxins are necessary. Numerous attempts have been made to produce anticrotalus serum, but until recently they have been unsuccessful, because the intense local reaction caused by these poisons killed the animals used for the production of the serum. The problem in producing anti-viperine serum has been to find some way of destroying the intense local effects of the venom without injuring its antitoxin-producing power. The work

of Flexner and Noguchi with crotalus venom leads us to believe that the problem has been solved, and it is now possible to produce an anticrotalus serum. This end was attained by treating the crotalus venom with chemical substances which converted the toxin into toxoid, removing the irritating local effects, but leaving the antitoxin-producing power unharmed. As far as we know, the anticrotalus venom has not been used in cases of human poisoning. It, as well as a moccasin antivenin, may be obtained from the Rockefeller Institute in New York. Cobra and daboia antivenins are furnished in India, Notechis antivenin in Australia, and Lachesis antivenin in Brazil and Japan.

To accelerate the excretion of snake venom one measure seems worthy of attention, and that is gastric lavage. As shown by Alt, snake venom, like morphin and many other alkaloids, is excreted in part by the gastric mucosa, and it is well to practise lavage in these cases, repeating the operation at intervals of half an hour until the patient is out of danger.

The symptoms of imminent danger in these cases are respiratory and cardiac failure. For the respiratory paralysis artificial respiration is indicated. It should be kept up for a long time, for it is to be remembered that if the patient be tided over the crisis, recovery is often prompt, and this is especially characteristic of crotalus poisoning. The use of strychnin, introduced by Fayrer and Brunton, has been highly recommended, especially by Müller, of Sydney. According to this author it is almost a specific, and the failures under its use are attributable to insufficient doses. The sulphate should be given hypodermically in doses of $\frac{1}{6}$ grain, and should be repeated at half-hour intervals until slight tetanic convulsions appear. The tolerance to the drug in these cases is said to be remarkable. Rogers recommends adrenalin in poisoning by venoms whch paralyze the vasomotor centers. Atropin, in doses of $\frac{1}{120}$ to $\frac{1}{60}$ grain hypodermically, has been recommended as a cardiac stimulant. The use of alcoholic stimulants in moderation is of service, but the indiscriminate use of whisky in enormous doses (a quart or more at one sitting, for example), a much-vaunted lay remedy, cannot but lead to harm; indeed, it is a question whether some of the fatal cases of rattlesnake-poisoning have not been due to acute alcoholism rather than to the effects of the venom; Willson states that 5 per cent. of the mortality in the United States is from this cause.

The treatment of the local lesion is particularly important in poisoning by viperines, inasmuch as general sepsis may result from infection of the wound. In case the bite involves a finger or toe, it may be advisable to amputate the member, but the necessity for this must be decided by the judgment of the physician. The main point to be borne in mind is that the local injury must be treated with the strictest regard to asepsis and antisepsis. In order to prevent infection, the general resistance of the patient must be improved by means of an abundance of nourishing food, rest, fresh air, and general

tonics. The bite of the Gila monster (*Heloderma suspectum*) should be treated on the same principles as a snake-bite.

POISONING BY STINGING OR BITING INSECTS

1. **Bee, Wasp, and Hornet Stings.**—Bee-stings are, as a rule, of little import, though occasional fatal results have occurred in feeble individuals from multiple bee-stings. Even single wasp and hornet stings may give rise to severe symptoms. In India the sting of the common hornet (*Vespa orientalis*) may produce, besides local pain and swelling, faintness, with pallor, cyanosis, cold extremities, shallow, feeble respirations, and a rapid, small pulse. Many of the patients have a rigor and fever about two and a half hours after the sting was received. Usually the patient feels tired the next day. Wasp sting may produce similar, but less marked, effects.

Treatment.—There is no specific treatment. Hot applications to the site of the sting usually relieve the pain. The main thing is to tide the severer cases over the period of prostration, which seldom lasts more than twenty minutes or half an hour. The usual methods are to be employed: absolute rest, heat to the extremities, and strychnin or caffein hypodermically. The patient should be kept in bed until the day following the accident.

2. **Spider Bites.**—While there is little doubt that popular superstition has exaggerated the danger from the bites of poisonous spiders, there is reliable evidence that disagreeable effects, and even fatalities, may occur from them. In Egypt the *Chætopelma olivacea*, in New Zealand the *Katipo*, and in this country *Lathrodectus mactans* and *Phydippus tripunctatus* may cause serious symptoms. In the United States spider bites are most common in the south and southwestern States. The patient is most often bitten about the genitalia, as the poisonous spiders are found most frequently in country privies. The local symptoms are slight burning, followed in twenty or thirty minutes by severe radiating pains, often extending long distances from the site of the injury. In severe cases symptoms of collapse, with at times unconsciousness or convulsions, supervene. There may be intense restlessness, and in some cases bloody diarrhea or hematuria. Sloughing at the site of the wound and along the course of the lymphatics draining it may occur. Death in some instances has undoubtedly been due to sepsis, rather than spider poison.

Treatment.—This is essentially the same as the treatment of snakebite. If an extremity is bitten, a ligature should be applied, the wound should be freely incised, and moistened permanganate crystals should be rubbed in. Indigo solution as a local injection is recommended by many southern physicians. On account of the danger of secondary bacterial infection, these wounds should be treated under the strictest aseptic precautions. The general symptoms demand the usual stimulating treatment.

3. **Scorpion Bite.**—In some tropical countries the bites of scorpions

are not infrequently fatal, especially in young children. Fatal results rarely occur in individuals over twelve years of age. The symptoms are both local and general. The local symptoms are intense local pain, radiating from the injured part, with redness and swelling. The general symptoms are essentially those of collapse, with salivation and at times vomiting. Priapism is said to occur not infrequently, and there may be hallucinations.

Treatment.—Wellman states that the intense local pain may be relieved by plunging the affected limb into hot water. Incision of the wound and rubbing in of moistened permanganate crystals, as in snake-bites, should be practised. Calmette's antivenin has been used in at least one instance, but it is difficult to see how it could be of value. The symptoms of shock should be treated by the methods already described.

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DRUG POISONINGS AND DRUG HABITS

By Horatio C. Wood, Jr., M.D.

There are certain general measures which enter into the management of nearly every form of acute drug-poisoning, and may, therefore, be conveniently discussed as a sort of introduction to the consideration of the subject of the treatment of the individual poisonings.

In the great majority of cases the poison enters the system through the alimentary tract, and in these cases the first thought of the physician should always be to empty the stomach, unless, perchance, there is reason to believe this has already been thoroughly accomplished. In this connection it should be remembered that there may have been a great deal of retching and even vomiting without having completely rid the stomach of the baneful substance. There are two methods of evacuating the stomach: by the stomach-tube and by emetics. The stomach-tube, if at hand, is usually preferable when the poison has been taken in a liquid form; but for the ejection of solids it is of very little value. When the stomach-tube is employed, the stomach should be well washed with tepid water, in which may be dissolved the chemical antidote. This washing should be repeated several times, and after the final one the full dose of the antidote should be left in the stomach.

The stomach-tube is, however, frequently not to be had in emergency, and even if at hand, there may be obstacles preventing its use, especially in suicidal cases, so that the main reliance is upon emetics. One of the most generally useful of these is apomorphin, especially because it may be given hypodermically and because of the promptness of its action. In cases of narcotic poisoning, however, the vomiting centers being benumbed, apomorphin often fails to act, and in these cases it is not advisable to use it too freely, as in overdose it is depressant; if $\frac{1}{4}$ grain has not produced emesis, it is improbable that any quantity will do so. Under these circumstances the best remedy is usually zinc sulphate, which may be given in doses of $\frac{1}{2}$ dram, repeated in fifteen minutes if vomiting does not occur. In emergency a tablespoonful of mustard flour stirred into half a tumblerful of warm water will act as a prompt and efficient emetic, but is very unpleasant. If no more effective agent be obtainable, a warm solution (not hot) of ordinary salt will sometimes produce the desired result. Titillation of the throat with the finger or a feather may also be tried.

Most chemical antidotes act by forming relatively insoluble compounds—for example, the tannates of the alkaloids—which are, however, not absolutely insoluble, and are capable of being absorbed,

albeit with much less readiness than the original poison. In these cases, to lessen the likelihood of intestinal absorption, a prompt purgative is strongly indicated, of which by far the most serviceable are the salines—either Rochelle or Epsom salts. These should be given in doses of a tablespoonful dissolved in a full tumbler of water, the large quantity of fluid increasing the quickness of their effect.

For convenience of arrangement we have divided the poisons into three groups: 1, Poisons harmful chiefly because of their local influence—irritants. 2, Poisons affecting the general system, but also exercising a powerful local effect. 3, Poisons devoid, or nearly so, of local irritant action.

Irritants

Symptoms.—The effect of those poisonous substances which depend for their toxicity upon their irritant influence will naturally be most marked at those points which are reached by the poison in the most concentrated form; that is, with which the poison first comes in contact. It is evident, also, that a concentration of the toxic substance is likely to occur at points of elimination. Therefore, the irritant effects will be manifested most severely along the alimentary tract and in the kidneys, and we find, almost routinely, pain in the epigastrium, with nausea and vomiting, and frequently diarrhea, evidences of irritating influence upon the gastro-intestinal canal; albumin, tube-casts, sometimes blood in the urine, and in some cases partial or complete suppression. The precise symptomatology differs with the individual drugs according to their rapidity of action, the degree of their irritant properties, and the possession of other actions. For example, ammonia being a highly irritant and rapidly acting poison, we will find the evidences of its influence chiefly in the mouth, throat, and stomach, and coming on almost immediately; on the other hand, in such a poison as arsenic the symptoms may not appear for hours after the ingestion, and the intestinal and renal symptoms will frequently outweigh the gastric. The morbid manifestations must be described for each drug individually.

Certain complications and sequelæ are common to the whole group of irritant drugs. The most important of these are the collapse resulting from the exhaustion produced by the violent inflammation, and the interference with the digestive process during convalescence, which may be at times so severe as to lead to fatal results.

Treatment.—*Treatment Based on the Cause.*—The removal of the cause consists in either emptying the stomach or neutralizing the poison by the use of appropriate antidotes. Although most of the antidotes are peculiar to certain poisons and must be considered separately, a word or two concerning the so-called "general antidotes" may be in place. Of these, the most important are the various forms of albumin. Albumin forms comparatively inert compounds with nearly all the irritant poisons, including the corrosive alkalis

and acids, most of the metallic salts, iodin, etc. The best form of albumin for this purpose is the white-of-egg, of which from two to six eggs may be employed; milk or hashed meat offer alternatives. Soap is also an antidote of wide-spread utility, being antagonistic to the mineral acids and to most of the irritant metallic salts, especially corrosive sublimate and subsulphate of iron. This may preferably be administered by dissolving in four times its bulk of hot water, so as to form a thick suds.

The methods for emptying the stomach have already been sufficiently described. In this connection, however, it must be remembered that in many cases the vomiting may have been so excessive that antemetics are needed. On the other hand, where the vomiting is moderate, the drinking of tepid water will often aid in cleansing the stomach, and not only get rid of the poison, but, by removing the source of irritation, allay the vomiting. The mere dilution of the irritant will lessen its toxic power, but it must be noted that when the vomiting is not active, the water may aid the solution of the poison and hence encourage absorption. Some irritants are so slow in their action that considerable damage may be done to the system before emesis occurs; in these cases we have recourse to the means of producing vomiting already described. Ordinarily, the mechanical or irritant emetics are to be avoided, apomorphin being our most useful remedy, but in cases of emergency, even such irritant emetics as mustard may, if used promptly, save life. Brundage* advises great caution in the use of emetics or the stomach-pump in cases of corrosive poisonings, on account of the danger of rupture or perforation of the stomach.

Treatment Based on the Pathology.—The relief of the inflammation in the upper alimentary tract, due to irritant poisons, is essentially the same whether the mouth, the esophagus, or the stomach is involved. Astringents are generally too irritating to be of value in such an acute type of inflammation; all food should be absolutely withheld for forty-eight hours, at least, if the poisoning has been an at all severe one; demulcent drinks, such as mucilage of acacia or tragacanth, or olive oil may be administered at frequent intervals. The latter is especially useful in cases of poisoning by the caustic alkalis, because, by forming with them a comparatively non-irritant soap, it acts both as a direct sedative and as an antidote, and affords also some nutrition. Barley-water may also be employed as being soothing to the irritant mucous membrane, and yet acting in some degree as a food. If the inflammation in the mouth and throat is severe, much relief can be obtained by having the patient allow pieces of gum-acacia or similar demulcent substances to dissolve in the mouth.

To encourage the action of the kidneys and to lessen the irritating influence of the poison upon them, by far the most useful substance is water. As soon as the gastro-intestinal tract has been freed from

* Manual of Toxicology, 1905.

the irritant poison, so that there is no danger of hastening absorption, the patient should be encouraged to drink as freely as possible of tepid water. Hypodermic injection of physiologic salt solution may frequently be advantageously employed for the same purpose. Where the inflammation of the kidney is not of a high grade, the milder diuretics, as buchu and uva ursi, may be employed.

Among the demulcents, the decoction of flaxseed enjoys a considerable reputation as a sedative to renal structure. If the irritation of the kidney is severe enough to lead to suppression of urine, dry cupping over the loins may be practised.

Treatment Based on the Symptoms.—For the relief of the vomiting which frequently persists even after the complete removal of the poison, aside from the use of demulcent remedies, by far the most valuable drug is morphin in one of its various forms. Probably the best preparation in these cases is the denarcotized tincture of opium, which is especially valuable when there is diarrhea. Cocain may frequently be very useful, especially when there is pain. For this latter symptom orthoform, in doses of 1 or 2 grains, is also applicable. The treatment of the diarrhea does not differ essentially from that of other irritant diarrheas, bismuth and opium forming the basis of the treatment. Tannic acid is strongly indicated, but the ordinary preparations may prove irritating to the stomach. Some of the modern insoluble compounds of tannin would likely prove useful.

COLLAPSE

In the treatment of toxic collapse the most important drugs are strophanthus, digitalis, strychnin, cocain, atropin, alcohol, and ammonia, which should all be given hypodermically and freely.

Of these, digitalis is the most powerful, but is frequently too slow in its action for complete reliance to be placed on it. If given subcutaneously, it will usually act in fifteen or twenty minutes. The tincture is the preparation of choice, and should be used in large dose—20 to 30 minims may be given at once. Merck's German digitalin is also a valuable preparation, but must be used more freely than ordinarily advised to be efficacious; $\frac{1}{2}$ grain of digitalin corresponds in power to about 20 minims of the tincture. Strophanthus is less powerful, but somewhat more prompt in its action than digitalis. The glucosid strophanthin, which is now official in the United States Pharmacopœia, may be given in doses of $\frac{1}{100}$ to $\frac{1}{50}$ grain.

The most valuable remedy after digitalis is strychnin, useful because it is at once a circulatory and a respiratory stimulant. It acts rapidly, and may be repeated at short intervals until exaggerated reflexes give notice that the limit of tolerance has been reached. Less than $\frac{1}{20}$ grain hypodermically is useless. One-tenth may be safely administered if not repeated at too short intervals. Cocain and atropin are sometimes serviceable as adjuvants, especially as respiratory stimulants, but are much inferior to strychnin. More-

over, if used too freely, they produce secondary depression. The limit for cocain is about $\frac{1}{2}$ grain; for atropin, $\frac{1}{50}$ grain.

Alcohol as a stimulant has been alternately relied on as of the utmost utility, and condemned as capable only of harm. But while doubtless too much trust has, in the past, been placed on alcohol, it is certainly at times a valuable adjuvant. The experiments of Wood and Hoyt,* although demonstrating that alcohol is not a very powerful cardiac stimulant, seem also to indicate that its greatest influence is exercised in conditions of shock. The rapidity of its action is a point much in its favor, as it may maintain life long enough to allow the slower and more persistent stimulants to act. One to two ounces of whisky or brandy may be administered either per orem or hypodermically.

Ammonia by mouth is useless; subcutaneously it is prompt, but fugacious and of secondary power. Thirty to 60 minims of the official water or 10 grains of the carbonate may be injected. Ether has been used hypodermically, but is probably incapable of benefit. Adrenalin is of doubtful utility, but if injected intravenously, may be used cautiously as a temporary expedient; it should not be repeated on account of its strong tendency to produce pulmonary edema.

The use of nitroglycerin in shock and collapse is an absurd practice, founded on a misconception of its physiologic action. It is not a true cardiac stimulant, and is capable only of harm in these cases.

In the treatment of toxic collapse, as in other extreme conditions, better results are usually obtained by the simultaneous use of several stimulants than by relying on any one drug. Thus, by combining strychnin with alcohol, to the cardiac stimulation of the latter is added the vasoconstricting action of strychnin, and if to these two we add digitalis and atropin, we obtain the maximum effect on the circulation with the minimum disturbance of the other bodily functions.

The injection of physiologic salt solution is of great service in these cases, since it tends to maintain the action of the circulation, replaces the fluids of the body which may have been lost through the diarrhea, and encourages the excretory functions of the kidney. The salt solution should be preferably administered intravenously; in conditions of feeble circulation the writer has experimentally determined that it requires half an hour for sufficient saline solution to be absorbed from the subcutaneous tissues to influence the blood-pressure. The solution should be at a higher temperature than is ordinarily recommended; the difference between the temperature of the liquid in the reservoir of a fountain-syringe and that in the needle under the patient's skin or in the vein may amount to as much as 10° or 15° F., and if there is any virtue in maintaining the bodily temperature, it is evident that the injection of large quantities of fluid directly into the circulation at a temperature of 90° or 95° F. will largely counteract the effects of externally applied heat.

As regards the quantity of saline solution, there is much more danger of using too little than too much. As a considerable amount of water passes out of the system through the overaction of the bowels, almost universal in this class of poisoning, less than a quart of solution cannot be expected to exercise any marked effect, and three or four times this amount can usually be given with perfect safety.

The methods ordinarily relied upon for maintaining the bodily temperature, such as placing a hot-water bottle to the feet and covering the patient with a blanket, are utterly inadequate. Probably the best and often the only practicable and efficient mode of elevating the bodily temperature is to place the patient in the hot full bath of about 105° F. When, for any reason, this method of treatment is not available, it may be replaced by the use of the hot pack; or, perhaps better still, by warming a blanket in the oven and wrapping the patient in the hot dry blanket and then abundantly covering.

ALKALIS

All the caustic alkalis, sodium, calcium, potassium, and ammonium hydroxids, are capable, if in sufficiently concentrated solution, of acting as irritant poisons, but ammonia poisoning is the most common. As the symptoms and treatment are very similar for all, ammonia poisoning only will be described.

Symptoms.—After swallowing the water of ammonia or similar preparation, the irritant influence is manifested at once on the mucous membrane of the mouth and pharynx, as will be shown by the intense injection and infiltration of these parts. The edema of the throat may be so violent as to completely close the glottis and cause mechanical asphyxiation. It must not be forgotten that the swelling of the inflamed membrane may not reach its acme until some hours after the ingestion of the poison. The other symptoms of ammonia poisoning are intense pain in the throat, esophagus, and stomach, vomiting, with repeated retching, and pronounced prostration. Occasionally sufficient vapor may enter the respiratory tract from the mouth to cause severe laryngitis and bronchitis and give rise to aphonia.

The *postmortem* lesions show simply a high grade of inflammation and corrosion of the upper part of the alimentary tract.

The **prognosis** in ammonia poisoning depends on the quantity, and especially the concentration, of the poison which has been taken. The final outcome, however, is very uncertain; the gastritis may be so severe as to almost destroy the power of digestion, so that even if the patient survives the immediate danger, he may subsequently die of starvation, or remain a more or less permanent invalid. Another very frequent sequela of poisoning by a caustic alkali is esophageal stricture. One fluidram of stronger ammonia water has caused death, but an ounce has been recovered from.

Treatment.—Neutralize the alkali with any convenient dilute

acid—vinegar or lemon-juice will probably be the one most quickly obtainable. As all the acids, even vinegar, are local irritants, and when concentrated may add to the inflammation, the antidote should be well diluted. If no acid is to be had, the next best antidote is some fatty substance, as olive oil or linseed oil, which form, with the ammonia, a comparatively non-irritant soap. The oils have the further advantage that they are directly soothing to the inflamed mucous membranes, and in those cases which are not seen for some time after the swallowing of the ammonia, should be the sole antidote.

In cases in which the throat becomes edematous to an extent that interferes with respiration, the physician must be prepared to perform tracheotomy at a moment's notice.

After the subsidence of the immediate peril the danger in these cases is by no means at an end, for the caustic alkalis lead very often to such a wide-spread destruction of gastric mucous membranes as to make the nourishing of the patient impossible, and death may occur even weeks after the ingestion of the caustic; or, if not fatal changes, there may be, as a sequence, a cicatricial stricture of the esophagus or such lesion in the stomach as will leave the patient a chronic invalid. To lessen the liability of these subsequent dangers no food should be administered by the stomach for at least twenty-four to forty-eight hours after the poisoning; demulcent drinks, as mucilage of acacia or tragacanth, or olive oil should be administered at frequent intervals. Morphin hypodermically, or cocain spray to the throat, may be employed to relieve pain.

MINERAL ACIDS

Symptoms.—The symptoms of poisoning by the ordinary mineral acids—sulphuric (oil of vitriol), nitric, hydrochloric—are burning pain in the mouth, esophagus, and stomach, signs of corrosion of visible mucous membranes, vomiting of mucous or bloody material, with frequently marked collapse. Edema of the larynx may occur in poisoning by the stronger mineral acids. The diagnosis between the various acids can sometimes be made by the color of the stain on the skin or clothing; nitric acid stains the skin a deep golden yellow; hydrochloric acid, a lemon yellow; while sulphuric acid chars all organic matter, leaving a deep brown or black stain.

Prognosis depends not only on amount and concentration of the poison, but on the presence or absence of food in the stomach. The usually fatal doses are, for sulphuric or nitric acid, 1 or 2 drams; for hydrochloric acid, about $\frac{1}{2}$ ounce.

The postmortem findings are those of intense inflammation of the whole of the upper part of the alimentary tract.

Treatment.—The chemical antidote is any non-irritant alkali; baking-soda (sodium bicarbonate), washing-soda (sodium carbonate), or magnesia are to be had in nearly all households, and any one or all of them may be employed. On account of its irritant influence, ammonia is ordinarily to be avoided, but in the lack of a more suitable

antidote, might, if well diluted, be employed. Albumin in the form of milk or eggs is also useful.

The inflammation of the mucous membranes of the alimentary tract is treated after the neutralization of the irritant, as already outlined. (See p. 773.)

OXALIC ACID

Oxalic-acid poisoning may result from the ingestion of the acid itself, but more commonly it is caused by potassium oxalate, commonly known as salt of sorrel or salt of lemon.

Symptoms.—The symptoms in either case are those of toxic gastro-enteritis, the mass vomited being usually black or brown from the presence of decomposed blood, with marked collapse. Occasionally the local symptoms may be absent, the condition being manifested simply by profound collapse. After death there is found, besides the inflammatory conditions in the mucous membrane of the digestive tract and of the kidneys, crystals of calcium oxalate in various portions of the body, especially in the kidneys, which is characteristic of this form of poisoning.

Prognosis.—Oxalic acid is a peculiarly deadly poison, being not only a local irritant, but exercising a baneful influence after absorption. According to Taylor, the smallest fatal dose recorded is 60 grains; more than an ounce has been recovered from.

Treatment.—The chemical antidote to oxalic acid is chalk or some other form of lime, or magnesia. As but little can be accomplished after the poison has been absorbed, it is essential that the antidote be administered as promptly as possible. In emergencies, the lime may be scraped from whitewashed walls; tooth-powder is ordinarily made up on a basis of chalk, and offers an excellent antidote. The other alkalis, except magnesia, are in no measure antidotal to oxalic acid, the salts they form being equally as soluble as the acid and, therefore, equally as poisonous. The subsequent treatment is the relief of the gastritis by the use of demulcents, the other ordinary measures, and the combating of the collapse. (See pp. 773, 774.)

CORROSIVE SUBLIMATE

Symptoms.—The symptoms caused by corrosive sublimate are pain in the mouth, esophagus, and epigastrium, with violent vomiting and purging and salivation. The vomit and stools are bloody; the urine is albuminous and may be partially suppressed, or there may be marked hematuria. There is a profound collapse, due to the violent enteritis.

The *postmortem* lesions found after corrosive sublimate poisoning are high-grade inflammation and corrosion of all mucous membranes with which it has come in contact. There are also signs of irritation of the eliminative organisms, especially in the kidneys.

The **prognosis** in cases of poisoning by the bichlorid of mercury is almost always grave, for even if the patient escapes immediate death from collapse, the destruction of the mucous membranes of the stomach and intestines so greatly interferes with the digestive functions that there is danger of subsequent death from lack of nutrition. The ordinarily fatal dose is about 5 grains.

Treatment.—Bichlorid of mercury is so powerful a corrosive that no treatment, aside from immediate neutralization of the poison by a chemical antidote or prompt evacuation of the stomach, is of much value. The most effective antidote is some form of albumin, of which the white-of-eggs is the best. It must be remembered, however, that the albuminate of mercury formed in these circumstances is soluble in an excess of albumin, so that the too liberal application of the antidote can be harmful. The proper proportions should be, approximately, the white of one egg to each 4 grains of the poison. In the absence of egg-albumin, hashed meat or milk may be substituted, or in lieu of one of these, soap is of some value. If the vomiting should be delayed, a promptly acting emetic is of great service. For this purpose the theoretically most appropriate remedy is apomorphin, of which $\frac{1}{4}$ grain should be given hypodermically at once. In the absence of apomorphin, even such irritant emetics as zinc sulphate or mustard water, although theoretically contraindicated, may prove life-saving measures.

The subsequent treatment of the corrosive sublimate poisoning is the treatment of the gastro-enteritis, as outlined on p. 773.

IODIN

Symptoms.—Iodin has occasionally been the cause of an acute toxic gastro-enteritis, the vomit being brown, or in cases where starch has been in the stomach, dark purple. The injection of iodin into various cavities has given rise in some cases to cyanosis and collapse, with vomiting of iodin-containing material.

Twenty grains of iodin are said to have caused death, although 2 drams have been recovered from.

Treatment.—The chemical antidote to iodin is starch. This may best be exhibited in the form of a paste made by rubbing up corn-starch with water, or moistened bread may be used. The stomach or the cavity into which it has been injected may be washed out with a weak solution of potassium iodid, as this favors the dissolving of the iodin and the more complete evacuation. Care should be taken, however, that none of the iodid solution be left in the cavity; the washing should always end with plain water. The remainder of the treatment is purely symptomatic.

The various iodin compounds, especially iodoform, give rise to types of poisoning so different from iodin that they will be considered among the systemic poisons.

SILVER NITRATE

Symptoms.—The corrosive action of silver nitrate is less penetrating than that of some of the other irritants, and, therefore, although the poison produces, as a rule, vomiting and sometimes purging, there is rarely blood in the ejecta. The vomit will usually be white and curdy from the presence of the silver chlorid precipitated by the gastric juice, but becomes gray in color after a few minutes' exposure to the light. The stools will usually be black from the presence of the sulphid of silver unless hydrochloric acid has been administered, in which case they may be white. If silver nitrate is taken in solution of some concentration, it produces a blanching of the mucous membrane, but the white spots will in a short time become black by the oxidation of the silver. It also leaves black stains on the skin and linen wherever it comes in contact with them.

Besides the gastro-intestinal symptoms, there are usually nervous symptoms, as vertigo, coma, convulsions, and often disturbances of respiration.

The **prognosis** in silver-nitrate poisoning is usually favorable. According to H. C. Wood,* there are but 3 fatal cases on record.

Treatment.—There are several efficient chemical antidotes for silver nitrate; the choice between them in practice should depend upon which can be obtained the most quickly. Theoretically, the best antidote is hydrochloric acid or one of its salts; sodium chlorid is nearly always at hand in the form of ordinary table-salt, and is a very efficient antidote. If a chlorid is not to be had immediately, the alkalis, as sodium carbonate (washing-soda) or soap, may be employed. The sulphates are also precipitants for silver, and albumin in the form of milk or the white-of-eggs is useful, not only on account of its antidotal effect, but also through its soothing influence upon the mucous membrane of the stomach.

LEAD-POISONING

Acute lead-poisoning occurs from the ingestion of one of the soluble salts of lead, most frequently the acetate, commonly called "sugar of lead."

The **symptoms** are partially those of local irritation of the alimentary tract, but in many cases there occur also various forms of nervous symptoms, as severe neuralgic pains, vertigo, or stupor. In fatal cases coma, either with or without convulsions, may develop. The blue line upon the gums, so characteristic of chronic lead-poisoning, may be present, but is more commonly absent. The vomit will ordinarily be white and curdy, from the presence of lead chlorid. There may be purging, but more commonly constipation is present. The stools are usually dark gray or black, from the presence of sulphid of lead.

* Therapeutics, twelfth edition, 437.

Treatment.—The most efficient chemical antidote for lead is sulphuric acid or one of its salts. The most serviceable of these salts is either magnesium sulphate or sodium sulphate, which act not only by precipitating the lead, but also clean the intestines of the poison. If these are not at hand, any other soluble, non-toxic sulphate, as zinc sulphate or alum, may be employed. When none of these are to be obtained, sodium chlorid may be used as a chemical antidote, although the chlorid of lead is not so insoluble as the sulphate. Threatening failure of respiration and other special symptoms should be treated in the ordinary manner, and inflammation of the gastric mucous membrane as we have already outlined (p. 773). Any nervous symptoms which may remain as the result of an acute lead-poisoning are to be treated as described under Chronic Lead-poisoning.

COPPER

The soluble salts of copper, especially the sulphate (blue vitriol), have been responsible in a few instances for serious and even fatal poisonings.

The **symptoms** are vomiting, purging, with severe colicky pains, the vomit being bluish or greenish, occasionally bloody, the stools being mucous and at times bloody. There is also a coppery taste, excessive salivation, and frequently nervous disturbances, convulsions, delirium, or paralysis and death may occur in a few hours, probably from cardiac failure. Ordinarily fatal dose is ½ to 1 ounce.

Treatment.—As copper sulphate acts with great rapidity, it is essential that an antidote be given as soon as possible. The most efficient chemical antidote is potassium ferrocyanid (yellow prussiate of potassium). Unfortunately, however, this is not always to be had immediately, and in its absence some form of albumin, as milk or white-of-egg, should be employed. Soap may also be used.

For the cardiac failure, whisky, strychnin, digitalis, and similar stimulants should be employed.

COLCHICUM

Symptoms.—In poisoning by *Colchicum autumnale*, or meadow saffron, violent vomiting and purging, with large serous stools, form the most conspicuous features. The collapse which accompanies it is usually in direct proportion to the violence of the intestinal symptoms.

Prognosis.—As in fatal cases death practically always depends upon the violent purgation, the lethal result, if it occurs, is usually put off for several days after the onset of the symptoms. If the purging can be controlled, the prognosis is ordinarily favorable. Two and one-half drams of the wine of the root have taken life. Brundage* gives the fatal dose of colchicum root at 45 grains; of

* Manual of Toxicology, 1905.

the seeds, at a tablespoonful. After death from colchicum poisoning there is usually found an inflammation of the whole intestinal tract, involving especially the deeper glands and inflammatory changes in the kidney, but cases have been reported in which the postmortem findings were completely negative.

Treatment.—The only known chemical antidote to colchicum is tannic acid, although but little confidence can be placed in it. The main reliance must be washing out the stomach with large quantities of water or normal salt solution, which may contain 1 or 2 per cent. of tannin. The elimination of the poison through the kidneys should be encouraged by having the patient drink as freely as possible of water and by hypodermoclysis. For the relief of the purgation, opium, bismuth, and tannic acid, especially the first named, should be used liberally. Every effort should be made to maintain the nutrition of the body by the use of concentrated forms of food.

Poisons Acting Both Locally and Generally

ANTIMONY

Antimony poisoning is most commonly caused by the double tartrate of antimony and potassium—tartar emetic.

The **symptoms** are violent vomiting and purging, with profound collapse. The purging is of as violent type as that seen in any other form of poisoning. The stools are pure serum, with here and there flakes of mucus resembling closely the rice-water stools of Asiatic cholera. As a result of loss of water through the bowels there occurs the pinched expression of the face seen in cholera. The pulse is exceedingly small and very rapid; there is profound muscular weakness, with diminution in reflex activity.

Prognosis.—Although in robust individuals antimony usually causes vomiting early enough to prevent complete absorption, and recovery has taken place after the ingestion of large amounts (200 grains in one case), in persons of delicate constitution or where, for any reason, vomiting has been retarded, the poison frequently leads to a fatal result, the cause of death usually being heart failure, associated with general exhaustion. Two grains, it is asserted, has taken life.

Postmortem.—After death from antimony poisoning the mucous coat of the stomach and intestines will be found inflamed, with patches of ulcerations and sometimes covered with false membrane. There will probably also be signs of irritation of the kidney.

Treatment.—The chemical antidote to antimony is tannic acid. This should be given as soon as possible, and the administration continued from time to time, as the poison is probably largely eliminated through the intestinal glands. Tincture of opium should be freely used to check the vomiting and purging.

The collapse in antimony poisoning is extreme because it is brought

about not only through the violent purgation, but also through the direct depressant effect of the drug on the circulation. It is to be combated with the measures already outlined. (See p. 774.) The use of saline infusion has, however, here a peculiar value in replacing the fluid lost through the purgation. It must be borne in mind, however, in this connection, that an increased volume of blood means added work to the heart, which is seriously embarrassed by the poison, and the salt solution should not be used too rashly; 1 or 2 quarts should be the limit for a single injection, which can be repeated if deemed advisable.

ARSENIC

Symptoms.—Acute arsenic poisoning is characterized by violent vomiting and purgation, with free watery stools, cramp-like pains, profound collapse, with albuminous or suppressed urine and marked thirst. Various nervous symptoms may occur, either the sensory or motor tracts being affected.

After death from arsenical poisoning there will usually be found marked lesions in the mucous membrane around the pylorus and in other portions of the alimentary tract, and frequently wide-spread fatty degenerations. In some cases pathologic lesions have been observed in the nervous system. The minimal lethal dose is in the neighborhood of 2 grains. The fatal result may be delayed for several days.

Treatment.—The best chemical antidote to arsenic is the freshly precipitated sesquioxid of iron; the official ferri oxidum hydratum cum magnesio is to be preferred if readily at hand. As time is a question of importance, an efficient antidote may be extemporized from the tincture of the chlorid, or from Monsel's solution, with magnesia, washing-soda, or ammonia water, the precipitate separated by rapidly straining through a piece of cheese-cloth, and an amount of this precipitate equal to at least eight times the weight of the arsenic ingested should immediately be administered. If the official antidote has been obtained, it may be administered later, or a second dose of the extemporized one may be used. The antidote should be used freely, as it is absolutely harmless, and the larger the quantity employed, the quicker will be the neutralization of the arsenic. It is said that magnesia is also antidotal, but it is certainly inferior to the iron solution.

Opium should be freely administered to control the vomiting and diarrhea, and, if the latter is excessive, a preparation of tannic acid may also be exhibited. Large amounts of water by the mouth and hypodermoclysis are useful to keep up the kidney activity, as well as the circulation. The accompanying collapse is treated in the ordinary manner. (See p. 774.)

PHOSPHORUS

Symptoms.—The symptoms of phosphorus-poisoning usually begin with vomiting and muscular pains without purging. There is a matchy taste and the vomitus may be phosphorescent. The stools and even the urine are occasionally also phosphorescent. Later in the poisoning occurs "coffee-ground" vomit, frequently containing bile; there is generally constipation and light colored feces. The area of liver dulness is at first increased and then diminished; there is tenderness over the whole abdomen, especially in the area over the liver, and frequently distinct jaundice. The urine contains, besides albumin and tube-casts, leucin, tyrosin, and sarcolactic acid, the last of which is said to be pathognomonic of phosphorus-poisoning. There may be a large variety of nervous symptoms, of which convulsions, delirium, or local palsies are among the most common.

Postmortem Lesions.—After death from phosphorus-poisoning there are found wide-spread fatty degenerations, especially marked in the liver and kidneys, submucal and sometimes subdermal hemorrhages, and a peculiar inflammation of the glands around the pylorus, and also inflammatory changes in the kidneys.

Prognosis.—As is evident from the universality of the pathologic changes, the prognosis in a well-established case of phosphorus-poisoning is exceedingly grave. In this country the form of poisoning is fortunately quite rare, but in the large European clinics a mortality of 40 per cent. is given. The heads of two matches have caused death in a young child. The fatal dose of phosphorus is difficult to establish. One grain has taken life, and it is claimed that even smaller doses have proved fatal, although 5 grains have been recovered from. If finely divided or dissolved in oil, it is much more dangerous than in bulk. Death usually does not occur for several days.

Treatment.—In the treatment of phosphorus-poisoning the only possibility of improving the chances of the patient's recovery lies in the prompt neutralization of the toxic substance. Among the many antidotes which have been suggested, the two which stand out as of preëminent importance are copper sulphate and permanganate of potassium; as to which of these is the most valuable there is not unanimous agreement. The most rational mode of treating the poisoning would seem to be to give 5 grains of copper sulphate every five minutes until vomiting occurs or until a stomach-tube has been prepared. The stomach should then be washed out with a large quantity of solution of potassium permanganate in proportion of 1 : 500, leaving about a quart of the solution in the stomach. Hydrogen dioxid has been recommended as an antidote on the theory that it would oxidize the phosphorus, but in the experiments of E. Q. Thornton * it was of no value. Turpentine has proved of service in Europe, but the American turpentine is a different substance, and seems to possess no antidotal value.

* Therapeutic Gazette, 1893.

The inflammation of the alimentary tract seems to be a result of an effort of the pyloric glands to eliminate the poison rather than a direct irritation, and consequently treatment of the gastritis with demulcents is not likely to prove of great benefit. In this connection it must be borne in mind that phosphorus is freely soluble in fatty substances, and the use of oil or fat in any form is absolutely prohibited because it will encourage absorption. Symptom treatment in any case of phosphorus-poisoning holds out but little hope of success, but is to be tried after antidotal measures have been faithfully executed.

PHENOL

Symptoms.—The symptoms of poisoning by phenol, or carbolic acid, are intense pain in the mouth and stomach, usually vomiting, frequently also purging, with stupor and collapse. Upon the visible mucous membrane will be seen white, elevated and corrugated patches, the result of the caustic action of the drug. The urine will be smoky in color, usually albuminous, and occasionally bloody. The diagnosis of phenol poisoning is usually easy, on account of the odor of the drug. Half an ounce may be regarded as a probably fatal dose.

After death from carbolic acid corrosions will be found on the mucous membrane of the upper part of the alimentary tract; there will also be found a toxic nephritis.

Treatment.—For overcoming the local action of carbolic acid probably the most serviceable substance we have is alcohol. The value of alcohol, as shown by Asher,* is due to the fact that phenol is readily soluble in it and it acts as a diluent. It must be recognized, however, that although it lessens the local action of the poison it is likely to increase the constitutional symptoms if allowed to remain in the stomach. The sulphates have been used for many years in the treatment of carbolic-acid poisoning with the idea that they would form non-toxic sulphocarbolates. It has even been claimed that the salts of sulphuric acid are capable of following phenol into the blood and destroying it. The evidence, however, as to the antidotal power of the sulphates in carbolic-acid poisoning cannot be considered conclusive, but as they certainly do no harm, they should be employed.

The best method of procedure in carbolic poisoning is to wash out the stomach with diluted whisky or 20 per cent. alcohol, and follow this by the administration of $\frac{1}{2}$ ounce of magnesium or sodium sulphate. If the stomach-tube is not to be had, give 2 to 4 ounces of whisky diluted with equal parts of water and $\frac{1}{8}$ to $\frac{1}{4}$ grain apomorphin hypodermically. After free emesis give Epsom salts. The use of the sulphates in small doses (20 grains every two hours) should be continued until the patient is out of all danger. The subsequent treatment of the gastritis with demulcents is along the lines

* New York and Phila. Med. Jour., lxxix, 190.

already outlined (p. 773). It is recommended by some, however, that the oils be avoided as favoring absorption of the poison.

TANSY

The ordinary tansy of the garden (*Tanacetum vulgare*), or especially its volatile oil, is capable of producing serious or even fatal poisoning. It is asserted that 1 dram of the oil has caused death.

The **symptoms** have been abdominal pain, vomiting, loss of consciousness, violent convulsions.

Treatment.—There is no known antidote to the oil of tansy. The treatment must be purely symptomatic. Empty the stomach by the means already outlined, and maintain the action of the heart with proper stimulants.

BUTTERCUP

The common buttercup, *Ranunculus bulbosus*, contains an acrid principle, probably a volatile oil, and has in some cases caused violent and even fatal gastro-enteritis. The treatment is purely symptomatic.

SAVIN

Savin, which is occasionally used as a criminal abortifacient, contains an oil which, taken in overdose, produces violent abdominal pain, intense vomiting, and bloody purging, with albuminous, scanty urine and frequently nervous symptoms and collapse. Abortion occurs in pregnant women.

The **treatment** consists in emptying the stomach, if vomiting has not already occurred, with apomorphin, the cleansing of the intestines with castor oil, and the use of opium to relieve the vomiting and purging and the relief of the gastritis and the collapse in the ordinary manner. (See pp. 773, 774.)

SYSTEMIC POISONS

Those poisons which depend for their toxic power on their effects after absorption, rather than their local action, differ so widely in their effects that but little can be said of a general nature concerning them, except a brief reference to chemical antidotes. Most vegetable poisons depend for their activity on the presence of either an alkaloid or a glucosid. Both the alkaloids and glucosids form with tannic acid relatively insoluble compounds, and substances, therefore, which are rich in tannin, are useful as antidotes in cases of vegetable poisonings. The most valuable form of this antidote is the tannic acid itself in watery solution, although such substances as kino, catechu, oak-bark, and even tea contain more or less considerable amounts of tannin and may be employed. It must be remembered, however, that the tannates are not absolutely insoluble, but yield themselves

slowly to absorption and the antidote, therefore, should ordinarily be followed by a brisk cathartic, such as Rochelle salts. From 20 to 40 grains of tannin may be given, dissolved in half a tumbler to a tumblerful of water, and repeated at intervals of from fifteen minutes to half an hour, as the case may require.

Potassium permanganate is capable of destroying many alkaloids, and probably all of them. It has been shown experimentally by Fodera that this holds true for morphin, strychnin, veratrin, and helleborein. It may be given ordinarily in doses of 4 to 5 grains dissolved in a pint of water. For the purpose of washing out the stomach, solutions of 1 : 500 or 1 : 1000 may be employed.

The aqueous solution of iodin with potassium iodid is an almost universal precipitant for the alkaloids, and is probably the most valuable antidote we have for these poisons. The official Liquor Iodi Compositus (Lugol's solution) may be employed in doses of 20 to 30 minims.

Charcoal in powdered form seems to have the property of delaying the absorption of many poisonous principles, and in the absence of a direct chemical antidote may be used with advantage. It should be given freely in teaspoonful doses.

ANESTHETICS

Symptoms.—Speaking in a narrow sense, the condition of surgical anesthesia produced by chloroform and ether is really an intoxication, but as it is a condition so frequently produced intentionally, the symptoms which will be described as poison symptoms, of ether and chloroform, represent those which indicate danger in the course of surgical anesthesia. These danger-signals are sudden dilatation of the pupil, the loss of muscle tonus, as shown by changes in the expression in the face, drooping at the corners of the mouth, etc., stertorous breathing, an extremely rapid or feeble pulse, changes in the color of the skin, either pallor or cyanosis, great slowing or enfeeblement of the respiration.

Prognosis.—It is impossible in a treatise of this sort to satisfactorily consider the question of prognosis in these cases. Occasionally, under skilful management, the most desperate cases will recover. We shall, therefore, merely point out that the prognosis in chloroform poisoning is always more grave than in ether poisoning, not only because the anesthetic is more slowly eliminated, and therefore more persistent in its action, but also because it is a direct depressant to the heart. Both of these substances, it must be borne in mind, are capable of causing poisoning when swallowed and have, in fact, in several cases taken life. The probably fatal dose by mouth is given by Brundage as about one ounce of either poison.

Treatment.—At the first suspicion of danger in anesthesia the narcotic should be immediately withdrawn. If respirations have ceased, momentary attempts may be made to stimulate breathing reflexly

by pouring ether upon the abdomen or slapping with a wet towel, or by rhythmic traction of the tongue. As, however, these measures will probably prove futile, time should not be wasted in experimenting with them. Artificial respiration should be immediately resorted to. For this purpose Sylvester or similar methods may be employed, but much better results are obtained by the use of a forced artificial respiration apparatus, such as is described in connection with opium poisoning. (See p. 791.) As the anesthetics are largely eliminated from the lungs, artificial respiration is advisable even in those cases where the immediate danger is heart failure. On account of the palsy of the vasomotor mechanism, there is an accumulation of blood in the great abdominal vessels, and elevation of the feet, by aiding, through the force of gravity, the flow of blood to the right heart, is often a useful measure. Alternately elevating and lowering the feet has been recommended as encouraging the rhythmic action of the heart.

Within the last few years there have appeared a number of papers on the use of cardiac massage in desperate cases of chloroform collapse. I have frequently seen, in the lower animals, the action of the heart, which had entirely ceased as a result of chloroform poisoning, restored by rhythmic compression of this organ, and several cases of its successful employment in the human being have been reported.* Two routes have been suggested for reaching the heart for the purpose of performing massage; namely, by resection of the chest-wall directly over the heart and through the abdomen, either with or without opening the diaphragm. For the details of these operations we would refer to the article by Keen. König-Maas has reported favorably on massage of the heart through the chest-wall. His method consists in placing the ball of the thumb of the right hand immediately between the apex-beat and sternum, and making quick, sudden compressions of the thoracic wall at the rate of 30 to 100 times a minute. The value of this form of cardiac massage probably depends more upon the mechanical stimulus to the organ than any expression of blood. I have seen in the dog pulsations of the heart reëstablished by one or two vigorous slaps directly over the precordium. It should be emphasized in this connection that even if the cardiac pulsations are restored by the massage of the organ, they will not continue unless the blood is thoroughly oxygenated, and cardiac massage, therefore, without some efficient means of artificial respiration, is useless. Moreover, I believe that the forced artificial respiration, as produced with the bellows, does more than simply provide sufficient air; that the alternate expansion and emptying of the lungs acts as a sort of natural massage for the heart.

Among the drugs which are useful in anesthetic collapse stand preëminently strychnin and digitalis. In every case of anesthesia a hypodermic syringe loaded with 20 minims of tincture of digitalis, containing $\frac{1}{20}$ grain of strychnin sulphate, should stand ready at

* See Keen, Proceedings of the Philadelphia County Medical Society, 1904, vol. xxv.

the hand of the anesthetist. This dose of strychnin may be repeated once or twice at comparatively short intervals. Ammonia, hypodermically, cocain, atropin, and caffein are probably of service as subsidiary remedies.

Among the drugs which have been employed in those cases, but which are mentioned to be condemned, are nitroglycerin and alcohol. The physiologic action of neither of these remedies offers the least ground for expecting them to be of any service whatsoever. In fact, physiologically, they are both contraindicated, and in those cases in which they have been used and the patient has recovered, the favorable result has been in spite of the treatment, rather than on account of it.

The bodily temperature should also be maintained by the use of external applications of heat in the manner already described.

OPIUM

The most prominent symptom of poisoning by opium or its alkaloid, morphin, is sleep, which in the milder forms closely resembles natural sleep; the patient is easily awakened, but when left alone, immediately falls asleep again. The pupils are equally contracted, and in severe cases of poisoning are narrowed to a pin-point size. The respirations are slow, and in severe cases may fall to three or four a minute; the pulse is usually slow and full, and the skin, in the earlier stages, is warm and moist. The symptoms just outlined are those ordinarily seen in milder cases of poisoning, but a large quantity of morphin may produce a condition of coma and collapse, with profound stupor, from which it is impossible to arouse the patient, the pulse being very rapid and small, the respiration exceedingly slow and shallow, and the skin cold and clammy, with pupils contracted to a pin-point.

It must be remembered that opium enters into the composition of a large number of nostrums advertised to the laity, and while this class of preparations is more likely to give rise to the opium habit, they are occasionally responsible for acute opium-poisoning.

The **prognosis** in opium-poisoning in ordinarily healthy individuals depends very largely upon the skill with which the case is handled. Under skilful management most remarkable instances of recovery have been recorded. For example, Fell* reports a case following the ingestion of 33 grains of morphin in which artificial respiration was employed for seventy-two hours, the patient showing during this time no sign of spontaneous breathing. The smallest recorded fatal dose of opium is 4 grains; of morphin, 1 grain. There are no characteristic pathologic lesions left behind by the alkaloid save its chemical presence in the tissues.

Treatment.—Tannic acid has long been used as the chemical antidote for morphin, but it is probable that potassium permanganate,

* Med. Examiner, June, 1899.

as originally pointed out by Moor, offers a more efficient destroyer of the poison. Whichever is to be had most readily may be employed. It is well to administer one or the other of the chemical antidotes at more or less frequent intervals throughout the course of the poison, —about every hour,—as the alkaloid, being largely eliminated through the mucous glands of the duodenum, may reappear in the alimentary canal for absorption unless destroyed by the antidote. In evacuating the stomach the most satisfactory emetic is $\frac{1}{2}$ dram of zinc sulphate; apomorphin may be given hypodermically, and will often produce vomiting, although if the dose of opium has been large, the vomiting centers are often so benumbed as not to feel the effect of the emetic. More than $\frac{1}{4}$ grain of apomorphin should never be used, as in large doses it is depressing and will add to the effect of the opium. A tablespoonful of mustard in half a glass of tepid water is an efficient but unpleasant mode of emptying the stomach. If the stomach-tube is employed, it is well to wash out the stomach with 1 : 1000 solution of potassium permanganate, of which half a pint may be left behind in the stomach to neutralize any of the alkaloid eliminated by the bowel.

As death in opium-poisoning occurs almost without exception as the result of respiratory failure, all efforts, after the neutralization of the poison, are for the oxygenation of the blood. The value of the methods commonly employed for keeping the patient awake, as walking up and down, slapping with wet towels, etc., lies in the fact that the activity of the respiratory center is much diminished during sleep. Of the measures for combating somnolence in opium-poisoning, by far the most efficient is the electric brush. This causes an exquisite pain which will arouse any but the most deeply narcotized, and has the great advantage of being free from the danger of exhaustion which follows too vigorous walking, and leaves behind no unpleasant sequelæ, which are so frequently the result of well-meant but too violent flagellations. Alternate dousing with warm and cold water serves both as a preventive of sleep and a reflex stimulant to the respiratory center.

As a physiologic anatagonist to opium, atropin has enjoyed great repute. It must be remembered, however, that the only physiologic action of atropin which makes it of service in the treatment of morphin poisoning is its stimulant action upon the respiratory center, and that it is by no means the most reliable respiratory stimulant that we have. Moreover, if used too freely, atropin becomes a respiratory depressant and may prove more harmful than beneficial. More than $\frac{1}{50}$ grain should never be given. Probably the most reliable respiratory stimulant under these conditions is strychnin, of which from $\frac{1}{20}$ to $\frac{1}{10}$ grain may be given hypodermically. Reichert,* from physiologic experiments, has reached the conclusion that the most complete antagonist to morphin we have is cocain. He claims that it not only combats the respiratory depression, but also antagonizes

* Ther. Gaz., August, 1902.

the narcotic in its effect upon the circulation and metabolism. There is also clinical evidence to place this alkaloid among the useful remedies in the treatment of opium-poisoning; the dose may be ½ grain hypodermically. The alkaloid caffein is of service not only on account of its stimulant effect upon the respiratory center, but because, through its stimulation of the cerebrum, it tends to produce wakefulness; it is ordinarily employed in the form of strong coffee, of which a pint may be given per rectum. Sometimes, as an adjuvant to these drugs, ammonia, and in cases of circulatory failure digitalis, may be of service.

The hypodermic use of potassium permanganate has been recommended by Moor on the supposition that it was capable of following the morphin into the blood and there destroying it. The evidence, however, of any such action is far from convincing. Hypodermoclysis has also been recommended with the idea that it aided in the elimination of the poison.

If the measures outlined fail to maintain respiratory activity, the patient can usually be kept alive until the drug is eliminated, by the use of proper artificial respiration. The ordinary methods of artificial respiration, as the Sylvester method, are only partially efficient, and are exceedingly tiring to maintain for long periods of time. In cases of opium-poisoning, where it is necessary to have recourse to artificial respiration, much more satisfactory results will be obtained from "forced artificial respiration" by means of special forms of bellows, as in the apparatus suggested by Fell. An artificial respiration apparatus should form a part of the equipment of every modern hospital. It is of the utmost value not only in the treatment of opium-poisoning, but in other depressant poisonings, especially in respiratory failure occurring during anesthesia.

CHLORAL

Symptoms.—The symptoms of poisoning by chloral hydrate consist of sleep, the depth of which depends upon the dose which has been ingested, with marked reduction of reflex activity and muscular weakness; the pupil in the early stages is moderately contracted, and later becomes dilated; the pulse at first may be slow, but soon becomes rapid and feeble. The respirations grow progressively slower and shallower.

As the drug is a depressant not only to the respiratory center, but also to the heart, the prognosis in chloral poisoning is much more serious than in opium-poisoning. Death has been caused in more than one case by 30 grains. There are no characteristic postmortem lesions.

Treatment.—In the treatment of chloral poisoning it must be borne in mind that there is a simultaneous depression of both respiration and circulation. Death may be due to the failure of either function. There is no efficient chemical antidote, and the emptying

of the stomach, therefore, becomes of prime importance. For this purpose the stomach-tube is probably the best, and if emetics are used, only the locally acting emetics, as zinc sulphate, should be employed, on account of the depressant influence of the central emetics, as well as the fact that the centers will likely not respond to their influence.

For the maintenance of the respiration the measures recommended under opium may be employed, with the exception that nothing should be done which will throw any added strain upon the circulation. For this reason the walking with the patient and the use of flagellations, especially the former, should be carefully avoided, and the electric battery or the alternate hot and cold douches be relied upon to keep the patient awake. Strychnin is the physiologic antagonist of chloral in its effect upon the medullary centers (respiration and vasomotion) and on the spinal cord, and caffein combats the chloral in its action on the brain and respiratory centers; these should be used in all cases of chloral poisoning.

To maintain the activity of the circulation the patient should be kept absolutely quiet in a horizontal position, and circulatory stimulants used freely. Whisky by the mouth and ammonia hypodermically—either in the form of the water or in the form of the carbonate—are of some service, but digitalis is a more valuable drug. Thirty minims of the tincture of digitalis may be injected hypodermically, or Merck's German digitalin may be used in doses of from ½ to 1 grain. The quantities of this latter substance recommended in many text-books is too absurdly small to be of any service. If the failing circulation shows itself by falling of bodily temperature, external heat should be applied.

ALCOHOL

The **symptoms** of acute alcohol-poisoning are too well known to require description, and I shall only, therefore, call attention to two facts, the neglect of which has been the cause of death in many instances. The first is that many persons presenting symptoms apparently of alcoholism are suffering either from some disease or other form of poisoning. Even the characteristic odor of the drug upon the breath cannot be held to be pathognomonic; it is quite possible, for example, for a patient under the influence of alcohol to have an attack of apoplexy, or for two forms of intoxication to exist simultaneously. The second important fact is that the common belief that alcohol-poisoning is a trivial complaint is far from the truth. It has been asserted that more persons die from acute alcohol poisoning than from any other form of acute poisoning. Death in these cases is usually from heart failure. The prognosis, however, in individuals of ordinarily robust constitutions, if properly treated, is comparatively favorable.

Treatment.—In acute alcohol-poisoning empty the stomach

promptly with ipecacuanha (½ dram) or zinc sulphate (½ dram); the stomach-tube may also be used to good purpose. If failing circulation and respiration are imminent, sustain with strychnin, atropin, and digitalis injected hypodermically. External heat should be applied, as, on account of the peripheral dilatation of the vessels, there is likely to be a large dissipation of heat through the skin.

After acute alcoholism there occur a more or less definite congeries of symptoms, which are so frequent that a word is required as to the treatment of this condition. Following an acute debauch, especially if it has been prolonged for one or two days, the symptoms are those of irritation of the gastro-intestinal tract and of depression of the nervous system. There is almost always marked nausea, sometimes vomiting, the matters ejected being frequently bile-stained. The tongue is heavily coated, the breath is foul, and there is a peculiarly disagreeable taste. The bowels may be loose or constipated, the difference being dependent upon the form in which the alcohol is taken or the personal predisposition of the patient. In either case the movements will probably show the absence of bile by their light color. There are marked irritability and nervousness, and occasionally a mild degree of insomnia, these symptoms being due, in part, to disturbance of the stomach, and in part to a specific action of the drug upon the nervous system.

In the treatment of this condition the first measure should be a thorough cleansing of the gastro-intestinal tract, both the stomach and intestines. A full dose of ipecacuanha has the double advantage that it empties the stomach of any of the poison which may be left behind, and that both by virtue of its emetic action, as well as through a direct influence, it tends to establish the hepatic secretions. Calomel, on account of its cholagogic action, is ordinarily the most serviceable cathartic. To aid in the elimination of the poison already absorbed free sweating is a useful measure. This is best accomplished by the use of heat, although pilocarpin may be used as an adjunct. The milder diuretics, as potassium tartrate, are also useful to encourage elimination of the poison.

For the purpose of quieting the nausea the most useful remedies are the more active stomachics. Capsicum has achieved a great popular reputation as a remedy in the treatment of alcoholic gastritis, and is frequently a valuable drug; the oleoresin, in doses of ½ to 1 minim, or the tincture, in doses of 10 to 30 drops, may be used. The oleoresins of pepper or of ginger are also useful, although less popular. One of these may be combined with great success with a bitter tonic, especially nux vomica. The diet should be light, easily assimilable, and highly seasoned, as broth or soups. To quiet the nervousness, sodium or ammonium bromid, in doses of 20 to 30 grains, may be given. If there are signs of circulatory weakness, strychnin or, in severe cases, digitalis may be employed (For treatment of delirium tremens see p. 805.)

METHYL-ALCOHOL

This substance, which is known variously as wood-alcohol, Columbian spirits, or pyroligneous spirits, is a treacherous poison, which has frequently led to accidental intoxication through its fraudulent substitution for ethyl-alcohol, especially in the preparations of aromatic spirits, as the spirits of peppermint and the essence of ginger. It is capable of producing an intoxication very similar to that caused by ethyl-alcohol, but of extraordinary duration, lasting from three to four days, which is frequently accompanied by more or less violent convulsive movements. The pupil is usually dilated, and nystagmus is a not uncommon symptom. Even from a single dose, but more commonly from its repeated ingestion, there may follow a permanent amblyopia.

The prognosis in an individual case of poisoning by methyl-alcohol is very uncertain as regards the occurrence of blindness. After the onset of blindness, although temporary improvement may occur, 90 per cent. of the cases end in permanent impairment of vision. Moulton reports an instance in which 5 men each drank about one-half pint of wood-alcohol.* Two of these recovered entirely, two died, and the fifth was permanently blinded.

The postmortem lesions produced by this poison are degenerative changes in the ganglion-cells of the retina and wide-spread fatty degenerations, especially of the liver.

Treatment.—The treatment of methyl-alcohol poisoning is very unsatisfactory. If the patient is seen during the stage of active intoxication, the stomach should be washed out, preferably with the stomach-tube, or by the use of suitable emetics; stimulants, as digitalis and caffein, should be used to meet any symptoms of collapse which may occur.

The subsequent treatment should be directed with the aim of aiding the elimination of the poison by encouraging free sweating and the administration of large quantities of water. As there is reason to believe that the toxic effects of this substance are due, at least in part, to the liberation of formic acid in the system,† the use of alkalis, as the carbonate of soda, would seem a rational method of treatment. For the subsequent amblyopia strychnin and potassium iodid may be tried, but it is not probable that there will be any permanent improvement of vision.

VERATRUM VIRIDE

The symptoms of veratrum viride (green hellebore) poisoning are violent vomiting, sometimes with purging, profound muscular weakness, with diminution of reflex activity; pulse at first extraordinarily slow, but in the later stages becoming rapid and feeble; respira-

* Jour. Amer. Med. Assoc., 1901, vol. xxxvii, p. 1448.

† See Reid-Hunt, Johns Hopkins Med. Bull., August and September, 1902.

tions diminished from the beginning; cold clammy skin, and the other signs of extreme collapse.

On account of its emetic action, veratrum has been taken in enormous doses without fatal result; in one case a tumblerful of the tincture was recovered from. On the other hand, if emesis is not promptly produced, the outlook after ingestion of even moderately large quantities is grave. One dram of the fluidextract has ended fatally.* Death is ordinarily due to heart failure, but in some cases the depression of cardiac activity is the predominant factor in the lethal result.

Treatment.—Give tannic acid as antidote and empty the stomach, if necessary, in the ordinary manner. (See p. 771.) On account of the powerful depressant action on the heart, everything which tends to throw any added strain on this organ should be sedulously avoided. For this reason the patient is to be rigidly maintained in the horizontal position, not even allowed to sit up to vomit, but have the head turned to one side and vomit into a towel. The action of veratrum on the circulation is chiefly through the pneumogastric nerve; this effect is completely antagonized by atropin, which drug should always form part of the treatment of this poisoning. For the respiratory failure strychnin, cocain, and caffein are useful; the circulatory stimulants, whisky, digitalis, etc., and the other measures for collapse are indicated. (See p. 774.) If the vomiting is excessive, give full doses of morphin hypodermically, or laudanum per rectum. In severe cases artificial respiration is necessary.

LOBELIA

The **symptoms** of lobelia poisoning are violent vomiting, usually without purging, and with profound collapse, as shown by a rapid, feeble pulse, cold, clammy skin, shallow, irregular respirations, and profound muscular weakness. The depression of the respiration is usually disproportionate to the other symptoms.

Although the poison is a very virulent one, the majority of cases recover on account of the prompt emesis preventing the absorption of large doses. There are no characteristic postmortem lesions. Death is from respiratory failure.

Treatment is similar to that of veratrum poisoning. The chemical antidote is tannic acid.

CONIUM

The *Conium maculatum*, or hemlock, although indigenous to Europe, has been introduced in this country, where it is now found growing wild; it is a virulent and peculiarly lethal poison.

The **toxic symptoms** are profound muscular weakness, associated with collapse, and frequently various eye symptoms, as ptoses of the eyelids, dilatation of the pupil, and paralysis of accommodation; vomiting may or may not occur.

* Phila. Med. Times, vol. xiv.

The **prognosis** in cases of any severity is always grave; the postmortem lesions are not characteristic. The treatment is precisely similar to that of veratrum poisoning. (See p. 795.)

GELSEMIUM

The **symptoms** produced by *Gelsemium sempervirens*, or yellow jasmine, differ only from those of conium poisoning in the fact that the pupil is very rarely affected, and there is very frequently a peculiar dropping of the jaw. The plant is probably a less virulent poison than conium, but the treatment is exactly the same.

CICUTA

A number of the species of the genus Cicuta are virulent poisons. Of these, *Cicuta maculata* (water hemlock, cowbane, snakeweed, spotted cowbane, etc.), *Cicuta vagans* (Oregon water-hemlock), and *Cicuta occidentalis* are among the most deadly poisons indigenous to this country. The symptoms produced have been dizziness, convulsions followed by paralysis, dilated pupils, and collapse. Violent vomiting has been observed in some instances; these cases offer a somewhat more favorable prognosis. For treatment, see under Veratrum.

NUX VOMICA

The **symptoms** of poisoning by nux vomica or its alkaloid, strychnin, usually come on with great suddenness. They consist of violent convulsions, which are usually at first tonic in character, but later become clonic. The convulsions may last anywhere from a few seconds to several minutes. Between the convulsions the respirations are hurried, the reflexes greatly exaggerated, the pulse strong and irregular. Intellection is not interfered with except in the later stages of fatal cases.

The **prognosis** in strychnin poisoning is usually in more or less direct ratio to the severity of the symptoms. The smallest fatal dose recorded in the adult is ¼ grain of strychnin. Death is usually from mechanical asphyxia, due to the rigidity of the thoracic muscles, although occasionally this danger is survived and the patient dies of exhaustion after several hours.

After death, postmortem rigidity comes on promptly and is well marked. There is usually more or less congestion of the internal organs, especially of the spinal cord, but outside of this and the rigor mortis, postmortem lesions are not characteristic.

Treatment.—It is to be remembered that in the great majority of cases death occurs from asphyxia brought about by the violence of the convulsion; it is to be further remembered that these convulsions are reflex in origin, and any form of sensory stimulus is liable to start a convulsion which may prove fatal. For this reason the

use of the stomach-tube after the onset of the symptoms is absolutely forbidden. And the same probably also holds true of emetics. Under these circumstances the question of antidote becomes of primary importance. Probably the most valuable antidote is potassium permanganate. In the absence of this, tannic acid or finely powdered charcoal may be employed, or the compound solution of iodin, as recommended by Prescott. (See Atropin, p. 799.)

Although our means of preventing the absorption of strychnin are so unfortunately limited, we have a variety of methods of lessening its baneful effects after absorption. Any drug for this purpose, to be of service, must act with extreme promptness. The most rapidly acting, as well as one of the most powerful, depressants for the spinal cord is amyl nitrite, which is preferably given by inhalation, but may, in the acme of the convulsion, be administered hypodermically—dose, 3 or 4 minims. The next most powerful depressant in these circumstances is chloroform, which, however, cannot be administered during the convulsion, when respiration has ceased; between the convulsions inhalations of chloroform should form the basis of the treatment. The anesthetic should be pushed to the stage of complete narcosis, by which means the convulsions may usually be completely arrested. After the patient is thoroughly under the influence of chloroform, a stomach-pump may be passed, and any remnant of poison left washed out of the stomach. Ether may be substituted for chloroform when the latter is not available, but is less prompt in its action and also less powerful. In the absence of these volatile depressants, the most quickly acting and, therefore, the most useful remedy we have is chloral, of which 20 or 30 grains may be administered. As soon as the more quickly acting remedies have temporarily controlled the convulsion, large doses of potassium or sodium bromid, 2 to 4 drams, should be administered per rectum. Other remedies which have been suggested, but which are of doubtful utility, are physostigmin, paraldehyd, atropin, and curare; the last two named, we believe, are more capable of harm than of benefit.

Artificial respiration for the relief of threatened asphyxia during the convulsion has been suggested, but is not likely to be of service. Certain it is that with the ordinary methods, such as Sylvester's, it is absolutely impossible to move any air in or out of the lungs in face of the spasm of the thoracic muscles, and the handling which is necessitated in producing this method might easily tend to prolong the convulsions. It is possible, however, that the forced artificial respiration apparatus might be of some benefit, but we know of no case in which it has been employed.

PICROTOXIN

Picrotoxin is the poisonous principle of the *Cocculus Indicus*, or fish-berries (*Anamirta paniculata*); probably also of the *Phytolacca decandra*, or pokeberry. Its chief importance as a poison lies in the

fact that it is sometimes used as the basis of "knock-out" drops for criminal purposes.

The symptoms produced by it are nausea, with free salivation and frequently vomiting. There are dizziness, mental confusion, drowsiness, and, if the dose is large, profound stupor. Convulsions after large doses are a frequent symptom; these are usually clonic, but in some cases tonic convulsions have been noted early in the poisoning. The pulse is at first slow, the respirations increased. Later, however, there is rapid, feeble pulse and shallow, inefficient respiration.

The fatal dose of picrotoxin is not definitely known, since the majority of cases of poisoning have resulted from the ingestion of unknown amounts of liquor containing indefinite proportions. According to Reid Hunt,* 2 or 3 grains constitute a dangerous dose. Postmortem lesions are not characteristic.

Treatment.—Treatment consists in emptying the stomach, controlling the convulsions, if violent, in the manner outlined under strychnin-poisoning, and the use of stimulants for threatening collapse.

In the treatment of the convulsions it must be remembered that the large doses of picrotoxin are depressing to the heart, and that, therefore, chloral and chloroform are to be used with great caution. There is no known chemical antidote.

SOLANACEOUS PLANTS

A large number of plants belonging to the family of the Solanaceæ, or nightshade family, many of which are indigenous to this country, are capable of giving rise to serious and even fatal poisoning. The most important of this group includes the *Atropa belladonna* (deadly nightshade), *Datura stramonium* (thornapple or jimson-weed), and several other members of the genus Datura, *Hyoscyamus Niger* (henbane), *Scopola carniolica*, and *Nicotiana tabacum* (tobacco plant). With the exception of the last mentioned, all these plants depend for their toxic properties on the presence of one or more of a group of alkaloids very similar in their physiologic actions, and which have been grouped together under the name of the solanaceous alkaloids. The most important members of this group are atropin, hyoscyamin, and hyoscin (or scopolamin). The physiologic action of hyoscin, while in many directions similar to that of atropin, has certain points of variation, but the symptoms of poisoning by these two alkaloids, while not precisely similar, are nearly enough so to be considered together.

Death from poisoning by these alkaloids is a rare accident, and in each instance, when it does occur, it is to be attributed to failure of respiration. We know of no fatal case of hyoscin poisoning in a healthy individual, but atropin has in several instances proved lethal, in one case as small an amount as $\frac{1}{30}$ grain hypodermically being followed by death.

* Peterson and Haines: Text Book of Legal Medicine, 1904, vol. ii.

Symptoms.—Usually the earliest symptom of poisoning by one of the nightshade family is dryness of the mouth and throat, which may in some instances be associated with loss of voice. Another early symptom which is common to the whole group is dilatation of the pupil. The patient is talkative, delirious, but in the case of hyoscin, the delirium may be more or less completely hidden by somnolence; the pulse is usually rapid and hard; the skin is dry, hot, and flushed, and in some instances there is an erythematous rash. The respirations are usually hurried in the earlier stages of the poisoning, but in fatal cases become very shallow and irregular. Convulsions may be present, but ordinarily do not occur.

The postmortem lesions are not characteristic, and the chemical recognition of this group of alkaloids is extremely difficult. In cases of suspected poisoning, however, the physiologic test of instilling a few drops of the urine into the eye of a cat or dog and noting whether it dilates the pupil is usually sufficient evidence that the poison is some member of this family.

Treatment.—Tannic acid is the most frequently employed antidote, but Prescott* recommends the compound solution of iodin (Lugol's solution), in the proportion of about 1 dram to 1 grain of atropin. The stomach should be thoroughly emptied. If the case is not a threatening one, usually all that is necessary is to quiet the delirium with the use of morphin and the bromids. Both pilocarpin and physostigmin exercise on many organs of the body an antagonistic action to atropin, and there is, as far as pilocarpin is concerned, some evidence, both clinically and experimentally, as to its value in belladonna poisoning, and while the question of the benefit of physostigmin has not been definitely proved, our knowledge of the physiologic action of the substance certainly justifies, if it does not demand, at least a trial of either or both of these drugs. One-quarter grain pilocarpin hydrochlorate, or $\frac{1}{30}$ of physostigmin salicylate, may be injected hypodermically.

In serious cases, where respiratory failure is imminent, there are at least two respiratory stimulants which may prove of value, namely, strychnin and caffein. The writer has frequently seen in the lower animals the respiratory function, which had been almost completely abolished by large doses of atropin, promptly restored by the conjoint use of these remedies, and even stimulated to an abnormal activity.

PRUSSIC ACID

The **symptoms** of prussic-acid poisoning move with such great rapidity that the physician is rarely called upon to treat a case, much less make a diagnosis; but in mines and other places where the salts of hydrocyanic acid, especially potassium cyanid, are largely used, the proper antidotes should be kept constantly on hand, and occasionally a case of poisoning by this drug may be saved. The symp-

* Peterson and Haines: Toxicology, 1904.

toms, which come on abruptly, are practically those of asphyxia: cyanosis, wide, staring eyes, frothing at the mouth, and, in many cases, convulsions. The pulse at first may be full and slow, owing to the asphyxia, but soon becomes rapid and feeble.

Prussic acid is one of the most virulent poisons known, even the inhalation of its vapors having in some instances caused death. Fatal cases usually end in five minutes, although occasionally death may be delayed for fifteen or twenty minutes. The immediate cause of death is asphyxia. After death the characteristic odor on opening the body is usually sufficient evidence as to the cause of death. Indeed, great caution should be observed in making postmortems in cases of suspected poisoning by hydrocyanic acid, as it is claimed that sufficient of the vapors may be inhaled under these circumstances to poison the pathologist. The only other changes characteristic are in the blood. The blood immediately after death is usually bright red over all the body, even in the veins; occasionally chocolate-colored blood, due to the presence of methemoglobin, may be observed.

The **treatment** of prussic-acid poisoning, to be of any avail, must be undertaken with great promptness. Two forms of chemical antidotes have been suggested—those which oxidize the acid, of which the most valuable is hydrogen dioxid, and the salts of iron, which form a comparatively non-toxic ferrocyanid. In cases where the poison has been ingested by the mouth, it is possible that the immediate administration of a solution of hydrogen dioxid or the ferric chlorid by the mouth might destroy some of the poison in the stomach before it has been absorbed. In the majority of cases, however, the poison has already been absorbed before the case is seen by the physician. The best that can be done is the hypodermic administration of strychnin in large doses, and the practising of artificial respiration.

In factories, however, where potassium cyanid is used it would be well to keep the antidote on hand, with one of the special apparatus which have been devised, as, for example, that of Merck.*

NITROBENZENE

This substance, which is also known as nitrobenzol, is used to a large extent as a flavoring substance, and is sometimes spoken of as the artificial oil of bitter almonds. The majority of cases of poisoning by it have occurred in factories making pomades and sweetmeats. After its internal ingestion, symptoms may not appear for as long as two or three hours, but when they occur they come on quite suddenly. In a general way the symptoms resemble those produced by prussic acid. The face assumes a peculiar bluish pallor, the lips and nails being purple; the pulse is weak and rapid; there is dizziness, with unsteady gait; fall of temperature; irregular respira-

* See Merck's Archives, vol. ii, p. 94.

tions; convulsive twitchings, and coma. The breath and urine have the odor of bitter almonds.

The minimum fatal dose is about 15 drops. The postmortem findings are fairly characteristic. The most important of these is the marked odor, which may be differentiated from hydrocyanic acid by the fact that it persists for some time even after opening the body. The blood is fluid, dark brown, and there may be ecchymoses in the alimentary tract.

Treatment.—The treatment is the immediate evacuation of the stomach if the poison has entered the system through this channel, the maintenance of the circulation and respiration with the ordinary means. (See pp. 771, 774.) Alcohol, however, should be sedulously avoided, as it encourages the absorption of the remedy.

DIGITALIS

The digitalis glucosids are the most prominent members of a considerable list of glucosids closely allied in their physiologic and toxic properties. These substances are characterized physiologically by their remarkable effects upon the cardiac muscle, by virtue of which, when taken in sufficient quantity, the ordinary stimulation and increase of power passes into such a state of overstimulation that the heart is thrown into a nearly complete spasm, which prevents its normal function. The more important plants containing glucosids of this group include digitalis, strophanthus, squills (*Urginea maritima*), lily-of-the-valley (*Convallaria majalis*), Canadian hemp or dog-bane (*Apocynum cannabinum*), and black hellebore (*Helleborus niger*). The oleander (*Nerium odorum*), which has caused severe cases of poisoning, probably contains a similar principle.

The **symptoms** produced by these drugs are very similar, and are as follows: nausea with vomiting, sometimes diarrhea, muscular weakness, and a pulse at first extremely slow and strong, and later becoming rapid, small, and hard.

The **prognosis** in digitalis poisoning is usually comparatively favorable, especially if the poisoning has followed but a single dose. The minimum fatal dose of digitalis appears to be 36 grains of the powdered leaves, although 1 dram has been recovered from.

Treatment.—The stomach should be promptly emptied, preferably by the use of zinc sulphate, 30 grains, or a similarly promptly acting emetic. Tannic acid may be administered as partial antidote, or the compound solution of iodin (Lugol's solution) may be used in doses of 20 to 30 minims. Aside from these measures there is but little can be done. Zugsmith* has reported an interesting case in which, basing his actions on the well-known fact that digitalis is less active in fevers, the patient was exposed to a hot vapor-bath at 120° F., with immediate relief of symptoms and subsequent recovery.

* American Medicine, 1901.

MUSHROOMS

Although the various species of mushrooms differ widely in their toxic effects, yet for practical reasons it has seemed well to group them under one heading.

The poisonous toadstools as far as known contain principles which act in one of four ways: (1) upon the central nervous system and circulation (muscarin); (2) destroy red corpuscles (helvellic acid and amanita-hemolysin); (3) produce protoplasmic degenerations (amanita-toxin); (4) local irritants. The greater number of cases of mushroom poisoning in this country are due to different members of the genus amanita, especially the *A. phalloides* (deadly agaric). According to the researches of W. W. Ford,* this mushroom contains two poisons, one of which is hemolytic and the other produces degenerative changes in the internal organs, especially the liver, kidney, spleen, and muscles. The *A muscaria* or "fly agaric" appears to contain, besides the basic principle muscarin, also a hemolytic poison. A number of these fungi produce an acrid milky juice which is capable of causing serious and even severe gastro-enteritis; this group has been given the generic name Lactarius.

The symptoms produced by poisonous mushrooms will vary according to the toxic principles which they contain. In the case of the deadly agaric (*Amanita phalloides*) the course of the poisoning is generally comparatively slow. The symptoms, which may be delayed for as much as twenty hours after the ingestion, consist of profound prostration, stupor, and sometimes delirium, with convulsions, frequently cyanosis, and in some cases icterus and hemoglobinuria. In poisoning by the fly agaric (*A. muscaria*), there are profuse sweating and salivation, with extremely slow pulse and great slowing of the respiration, contracted pupil, and sometimes delirium. In poisoning by the helvellas or morels the symptoms have been vomiting, jaundice, hemoglobinuria, and profound prostration. In the toadstools, such as those belonging to the genus Lactarius, which contain irritant principles, the symptoms presented have been simply those of violent gastro-enteritis: vomiting, purging, and collapse.

Treatment.—While in the case of most of these poisons we know of no chemical antidote nor any means of preventing the progress of the intoxication after absorption, in the case of the fly agaric proper treatment is of great service, and as the diagnosis between poisoning by the various mushrooms is generally uncertain, and the method of treatment will do no harm in other forms of toadstool poisoning, we may outline one general type of treatment. Empty the stomach with a hypodermic injection of apomorphin; follow this with $\frac{1}{2}$ a dram of tannic acid in solution; administer hypodermically $\frac{1}{50}$ of a grain of atropin sulphate. Atropin is the physiologic antagonist of muscarin, counteracting the poison in its effect upon the pneumogastric nerve, on the respiratory center, and on secretion, and is in cases of

* Jour. Exper. Med., 1906, viii, 437, and Jour. Pharm. and Exper. Ther., 1910, i, 275.

poisoning by the fly agaric a life-saving remedy. The stimulant action of atropin upon the respiratory center and upon circulation makes it also of value in other types of mushroom poisoning. Beyond this the treatment is purely symptomatic: the use of opium to check the vomiting or delirium as necessary, and the use of strychnin and digitalis and the other stimulants to combat the collapse.

ACONITE

The symptoms of poisoning by *Aconitum Napellus* (monkshood, wolfsbane) and allied species are those of collapse—rapid, feeble pulse, cold, pale skin, muscular weakness, and diminution of reflexes, associated with a peculiar tingling and numbness which is first felt in the lips, then in the extremities, and possibly all over the body, and is sometimes accompanied with anesthesia. This symptom is characteristic of aconite poisoning. Vomiting may occur, but is usually absent.

Aconite poisoning is always a serious intoxication. The prognosis is usually in direct relation to the severity of the symptoms. The minimum lethal dose of the root is 1 dram, but 25 minims of the tincture have caused death. Heart failure is the immediate form of death. There are no characteristic postmortem lesions.

Treatment.—Empty the stomach as promptly as possible with suitable emetic or stomach-pump; give tannic acid as probably the most efficacious antidote. To lessen the work of the enfeebled heart, the patient should be kept in the horizontal position, with the head low. The collapse is to be combated with the measures already described. (See p. 774.)

CHRONIC POISONINGS AND DRUG HABITS

Chronic Sulphonal Poisoning.—*Symptoms.*—The prolonged use of either sulphonal or trional frequently leads to a grave form of intoxication which, as a rule, comes on very insidiously. The first symptom, but one which may very easily escape notice, is a slight diarrhea followed by constipation. Usually, the first warning of the nature of the condition is seen in the discoloration of the urine, which varies anywhere from a pinkish tinge to a deep port-wine hue. The symptoms of a well-formed case are neurasthenia, insomnia, ataxic gait, irregular local palsies, loss of appetite, obstinate constipation, cramp-like pains in the abdomen, red urine containing albumin and tube-casts, but no blood or hemoglobin.

The prognosis in an established case is very serious; about 85 per cent. of them end fatally.

Postmortem Lesions.—After death there have been found widespread fatty degenerations, varying grades of nephritis, and staining of the tissues with hematoporphyrin (the substance to which the discoloration of the urine is due).

Treatment.—The high mortality of this poisoning is owing, at least in part, to the ignorance of its danger and of the proper modes of treatment. As large amounts of the sulphonal are probably lying undissolved in the intestines, being slowly absorbed, the first step is to see that the alimentary tract is thoroughly cleansed. For this purpose the most powerful cathartics are necessary; one or two drops of croton oil should be given and followed, if required, by a high turpentine enema. To aid in the elimination of the poison large quantities of water, by the mouth, in the form of salt solution hypodermically or by enteroclysis, is strongly indicated. The alkalis, as sodium or magnesium carbonate, have been recommended by Müller. Symptomatic treatment is of little avail, but should not be neglected.

Chronic Lead-poisoning.—*Symptoms.*—The manifestations of chronic lead-poisoning are so protean as to forbid a complete summary in this place. Cases of saturnism may be divided into two types—the alimentary and the nervous. The most important symptoms of the former are abdominal cramps of a peculiar twisting character, with marked constipation and loss of appetite. Of the nervous manifestations, the most frequent is the bilateral wrist-drop, from paralysis of extensor muscles of the arm. In other cases the symptoms may resemble acute poliomyelitis or locomotor ataxia. Saturnine cerebritis, which may simulate alcoholic delirium tremens, is not uncommon. The recognition of the etiology of these symptoms is of extreme importance, as the treatment of nervous inflammations of plumbic origin is essentially different from that of the idiopathic varieties. The most important diagnostic sign is the blue line on the gums. It must be remembered, however, that this may be lacking in lead-poisoning, in which case, in the absence of a history of exposure, diagnosis can be made only through examination of the urine for the metal.

The *prognosis* in chronic lead-poisoning with proper treatment is usually favorable, but certain of the nervous cases, especially those in which the cerebrum is involved, may end fatally.

The pathologic lesions of lead-poisoning, although not constant, are often well marked. In cases of nervous involvement there will be degeneration of the nerve-trunk or centers; there is frequently seen muscular atrophy; arterial sclerosis and hepatic cirrhosis have also been attributed to plumbism.

Treatment Based on Cause.—In the causal treatment of chronic lead-poisoning there are manifestly two steps—first, to stop the ingestion of the poison; second, to aid in its elimination.

In the majority of cases the source of the lead is not difficult to find, the great bulk of the cases occurring in persons whose occupations bring them in contact with the metal, as painters, workers in white-lead factories, plumbers, type-founders, and the like. In these cases it is essential that the patient, at least temporarily, abandon his occupation. In those instances in which the exposure is not from occupation, it is often very difficult to determine the source of the

intoxication. The most frequent mode of entrance is with drinking-water which has passed through lead pipes. Among the other less common sources may be mentioned the use of various cosmetics containing lead salts, the biting of silk threads of the cheaper varieties, which are frequently weighted with the lead, the use of various pottery and culinary vessels in which lead has been used in the process of manufacture, lead-foil around tobacco or confectionery, etc.

In ridding the system of any lead which has already entered, the first measure is thoroughly to cleanse the gastro-intestinal tract. For this purpose either Epsom salts or Glauber's salts is the best preparation, as, being soluble sulphates, they not only purge, but also precipitate any lead which may be in the alimentary tract. Potassium iodid, it is claimed, forms in the system a potassioplumbic iodid which is freely soluble and hence readily eliminated. Clinically, this drug seems distinctly to increase the rapidity with which the lead is excreted. The use of diuretics and sudorifics is probably of some value. Hot sulphur baths have been especially recommended, with the idea that the heat would stimulate the sweat-glands and that the lead thrown out upon the skin in this manner would be immediately precipitated as a sulphid. It is probable that in severer cases conjoint bleeding and hypodermoclysis would be of great value. In two cases of plumbic cerebritis the writer has seen life apparently saved in this manner.

Treatment Based on Symptoms.—The cramps which occur in saturnism are probably the result of spasm of the intestinal muscles, and those remedies which lessen the activity of the non-striated muscles are, therefore, indicated. Preëminent among these stands belladonna, or its alkaloid, atropin. This may be given in the form of the extract of belladonna, in doses of from $\frac{1}{6}$ to $\frac{1}{4}$ grain three or four times a day. Extract of opium is also efficacious in lessening the cramps, but its tendency to produce constipation is a drawback.

In cases in which the symptoms resemble those of poliomyelitis the proper symptomatic treatment is strychnin in ascending doses. In the beginning of the treatment $\frac{1}{15}$ to $\frac{1}{20}$ grain every three or four hours may be employed, increasing until there is evidence of heightened reflex activity, or twitching in the muscles. For the wrist-drop or other forms of saturnine neuritis full doses of strychnin, combined with electricity and massage, are of service. In plumbic cerebritis we have given large doses of the bromids, of chloral, and of paraldehyd and similar remedies without controlling in the slightest degree either the nervous excitement or insomnia.

DELIRIUM TREMENS

Occasionally a single debauch, even in a healthy individual, will lead to an attack of delirium tremens. Much more commonly, however, the disease occurs as the result of an acute alcoholic excess in a chronic drinker. Very frequently also in persons who have been

drinking heavily, but have shown no very positive signs of ill effects from the alcohol, the occurrence of some injury or of some disease will be the cause of a violent outburst of mania à potu.

The symptoms of delirium tremens are: delirium with hallucinations and delusions of fear, coarse tremors, marked insomnia, and digestive disturbances similar to those that have already been outlined following an acute debauch.

The **prognosis** in delirium tremens depends upon—(1) The general condition of the patient, especially the circulatory and excretory organs; (2) the number of previous attacks; (3) the existence of any complicating disease or injury. The first attack in healthy adults, if uncomplicated, nearly always ends favorably. The existence of minor surgical injuries greatly lessens the chance for favorable outcome; thus a sprained ankle makes the prognosis very doubtful, while a broken bone gives an almost absolutely fatal outlook. It is commonly stated that if the patient can be made to sleep, recovery will follow, and that if the patient awakes from the first sound sleep without material improvement in his mental condition, there will probably be permanent impairment of intellection. While there is a certain amount of truth in these beliefs, they can be accepted only with numerous modifications, and even then have many exceptions.

While alcoholism leads to many profound alterations of structure, there are no known pathologic lesions characteristic of delirium tremens. The disease is to be regarded as a condition of extreme exhaustion of the nervous system, to which is superadded the depressant effect of the large doses of alcohol.

Treatment.—At the time the patient is first seen by the physician there is usually not much likelihood of any of the poison being in the stomach or even intestines, but, unless there is an extraordinary asthenia, an emetic dose of ipecacuanha and a calomel purge at the beginning of the treatment are advantageous, not only to rid the alimentary tract of any unabsorbed alcohol, but also to aid in the reëstablishment of gastric and biliary secretions. By some apomorphin is preferred, on the theory that it not only has the beneficial effects of an emetic, but also exercises a sedative influence on the nervous system; it is asserted that, at least in the milder cases of this condition, the hypodermic injection of 1/4 grain of apomorphin hydrochlorid produces an emesis which is immediately followed by a refreshing sleep.

The most important factor in the treatment of mania à potu is the relief of the exhaustion. This is to be met, as in other similar states, by full nutrition and rest. The diet should be an easily assimilable one, highly nutritious and stimulating. These conditions are most nearly filled by the meat broths, which should be highly seasoned; the so-called "meat-extracts," however, contain very little nutritive material, and while occasionally useful as stimulants, are generally of but slight service. Likewise the "peptone" solutions contain more alcohol than nourishment. In cases of marked gastric

failure, predigested foods may be required. Usually the digestive organs will demand especial treatment; this should be similar to that in other forms of alcoholism.

In order that the patient have a chance to recover, it is essential that sleep be procured as speedily as possible. Certain writers have objected strenuously to the use of hypnotics in delirium tremens on the ground that they produce a disturbance of metabolism more harmful than the sleep is beneficial. Curiously enough, these same authors recommend the use of the bromids in large doses, which, although certainly much more feeble as sleep-producers, in all probability give rise to equal, if not greater, alterations in metabolism than paraldehyd or hyoscin or even chloral. Objection to one or two doses of any of these somnifacients, on account of some supposed effect on the nutritive processes, is certainly not warranted by our present knowledge of their physiologic actions. On the other hand, there is such urgent need of the restoration which can come only through sleep that not to promote sleep by every means in our power would seem a serious error.

Better results will ordinarily be obtained by the conjoint use of several, than by any one somnifacient. Chloral is perhaps the most powerful hypnotic we possess, but its depressant action on the heart is a serious drawback; morphin at times is of great service, but should not be used too freely. One of the most useful and least harmful of the somnifacients is paraldehyd. This may be given in doses of from $\frac{1}{2}$ to 1 dram. Hyoscin in dose of $\frac{1}{80}$ grain or more is another drug often of much service. The bromids, in our opinion, are not useful as somnifacients, but are often of great value to quiet the nervous restlessness in the waking periods. Ten grains of either ammonium or sodium bromid may be given every two or three hours.

For the circulatory weakness, digitalis is the most useful drug we have. Some authorities employ enormous doses ($\frac{1}{2}$ fluidounce of the tincture), but the possibility of harm from such quantities is greater than the probability of benefit. Equally good results can be obtained by the exhibition of 10 to 15 minims every two or three hours until the desired effect is brought about. Strychnin is also of service not only by virtue of its stimulant action on the circulation, but also because of its tonic effects on the nervous system. For some reason not apparent the nitrate is generally preferred in alcoholism; the dose is the same as that of the sulphate.

OPIUM HABIT

The treatment of drug habits in general, and more especially of the opium habit, can usually be carried out with more satisfaction in an institution devoted to this purpose than under any other circumstances. Certainly the treatment of a patient in his own home is nearly always fraught with serious difficulty. It is quite essential

that the physician have absolute control of the amount of opium the patient is receiving, and in a patient's own household this is well-nigh impossible. Moreover, a change of surroundings exercises frequently a beneficial mental influence upon the patient, and therefore when institutional treatment is impracticable for individual reasons, the patient should at least be removed to a hospital.

Treatment Based on the Cause.—The first step in the treatment of these cases is the withdrawal of the opium. It seems illogical to make, as many writers have attempted, any hard-and-fast rule as to the rapidity with which the morphin should be withdrawn. Varying factors enter into each case, all of which must be considered, and routine therapeutics is as unjustifiable in this condition as in any other disease. It would appear rational to wean the patient from his narcotic as rapidly as possible. If he is of fairly robust constitution, the habit of not too long duration, and the accustomed dose a small one, say, less than 5 grains of morphin per diem, the drug may be withdrawn abruptly. On the other hand, when the patient is of a neurotic type, or the constitution has been enfeebled by the use of the drug, the withdrawal must be more slow, and may cover a period of from one to three weeks, according to individual circumstances.

When the narcotic has been taken hypodermically, it is usually advisable to stop the use of the needle before undertaking the withdrawal of the morphin. The same amount that has been taken by hypodermic injection may be administered by the mouth for several days until the patient has become accustomed to the oral ingestion of the narcotic.

Even in well-managed institutions, during this withdrawal period especially, it is sometimes very difficult to be certain that the patient is receiving no opium beyond that prescribed by the physician. The statements of the morphinomaniac are absolutely unreliable, and the assertions of his friends and family are not much more trustworthy. It may be taken as a pretty safe guide that if the patient presents no disagreeable symptoms during the withdrawal period, he is receiving morphin from some clandestine source.

Treatment Based on the Symptoms.—When we have succeeded in withdrawing the drug entirely, and even when the patient has arrived at a condition where he is fairly comfortable without any opiate at all, cure is a long way distant; in fact, we may regard the handling of the case as merely begun. Kerr believes that any form of treatment in which the patient is not controlled for from three to six months, at the least, is practically useless.

The most common symptoms during and immediately after the withdrawal of the drug which require treatment are extreme nervousness and muscular unrest, hyperesthesia, vague pains, sometimes violent and sharply localized, insomnia, and various gastro-intestinal disturbances, nausea, vomiting, or diarrhea.

A large number of drugs, usually nerve-sedatives, have been highly lauded as specifics in the treatment of morphin and other drug

habits. It must be remembered, however, that these remedies are merely symptoms remedies. There is no substance known to man which is capable of regenerating a diseased moral nature, and although it is possible that some of these systems of treatment may make the withdrawal period less painful, none of them can be regarded as curative in the proper sense of the word. Moreover, it is extremely doubtful whether any of them are more valuable than the well-known nerve-sedatives.

For the quieting of the general nervousness, more can usually be accomplished by moral support and the use of physical agencies than by drugs. Hydrotherapy is of great service, and in severe cases almost indispensable. The Turkish bath, the hot or cold wet pack, the alternate use of hot and cold douches, have all of them been claimed to be the form of hydrotherapy most suitable for these cases. It probably makes little difference whether hot or cold applications are employed—the same stimulation of the dermal nerves and dilatation of the blood-vessels of the skin will be caused, and the patient's mind equally diverted, no matter in what form the water is applied. For the relief of lymph congestions, which is probably at the base of many of the hyperesthetic sensations, massage is of utmost value. Electricity of various forms, such as in neurasthenia, will also prove useful.

Among the drugs which are of service during this period as nerve-sedatives stand preëminently the bromids and the solanaceous alkaloids. Mattison has employed a system of the use of bromids in which, starting with 100 grains daily, the dose is rapidly increased to 200 grains, continued at this for three or four days, and then stopped. Kerr recommends that the bromids should be used only at night, and has found a combination of 20 grains of sodium bromid, 15 minims each of tincture of cannabis Indica and tincture of hyoscyamus, especially useful. The solanaceous alkaloids seem to have a peculiar, almost specific, effect upon the nervous system in various drug addictions. Of these, hyoscin is the most generally useful. Indeed, this remedy has been canonized into a complete system of cure. Dr. Lambert claims to have achieved most remarkable results by keeping the patient completely narcotized and unconscious for a period of seventy-two hours by the use of enormous doses of hyoscin hydrobromid. It is not at all probable, however, that this mode of treatment is of any greater value than any other symptom treatment. Dionin, a synthetic morphin derivative, has been recommended as almost completely relieving the craving for morphin during the withdrawal period. The writer has used it in but one case, without the slightest apparent effect. Alcohol and cocain have also been used for this purpose, but should be absolutely interdicted as likely to lead to a new form of drug habit.

For the relief of the extreme intestinal disturbances the diet should be almost completely restricted during the whole withdrawal period of treatment to broths and soups. The stomachics, espe-

cially the more powerful aromatics, as oleoresin of pepper or ginger, are frequently of service. The carbonated waters often exercise a very beneficial influence upon nausea.

During the period of convalescence following the withdrawal of the drug the treatment should be directed with a view of toning up the general health and nervous condition of the patient. A proper regulation of the diet, with out-of-door exercises under surveillance, the usual tonics, such as tincture of nux vomica or hydrastis, are indicated. During this period the patient should be carefully watched to prevent the obtaining of any form of opiate.

Even after the patient is sufficiently recovered to be trusted, he should by no means be regarded as cured. No matter how implicit may be his own self-confidence, if he or she returns to the accustomed round of work or social duties which has been the original cause of the acquirement of the habit it is almost certain that there will be a relapse. For this reason a prolonged vacation, preferably in some quiet resort in which plenty of exercises and fresh air are obtained, is essential. For male patients perhaps the most useful form of vacation is a camping expedition, either into the forests of Maine or Canada or in the Rocky Mountain wilderness.

SUNSTROKE

BY JAMES TYSON, M.D.

SUNSTROKE is a morbid state, the effect of high temperature upon the tissues and organs of the body. Abnormally high temperature is favored by numerous factors, among which are, first, high temperature of the surrounding air; second, excessive moisture in the air; third, stillness of the air, as contrasted with moving, stirring air; fourth, the direct action of the sun's rays; fifth, the amount of clothing investing the body, and its texture; sixth, personal susceptibility, especially influenced by the ability to perspire. Further explanation of the mode of action of these causes is unnecessary for our purpose. It is needless to say that tropical climates and hot seasons favor the occurrence of sunstroke, but its cause is not limited to the heat of the sun, artificial heat being a frequent cause, as evidenced by cases among stokers and furnacemen.

All the tissues, including the blood, share in this rise of temperature, whence occur deranged function and other symptoms. The morbid conditions resulting from exposure to high temperatures are not always the same, the extremes being simple weakness and faintness, on the one hand, and grave hyperpyrexia, on the other. They admit of classification, however, into two fairly well-defined groups: first, those of heat-exhaustion or heat syncope with lowered temperature; second, thermic fever, with a train of symptoms of which high temperature is the most striking. No more satisfactory theory in explanation of these different conditions has as yet been suggested than that of Professor Horatio C. Wood, based on studies made at the Pennsylvania Hospital as far back as 1863. His conclusions were as follows: "There is in the pons, or higher portion of the nervous system, a center whose function it is to inhibit the production of animal heat; and in the medulla oblongata a center (probably the vasomotor center) which regulates the dissipation of bodily heat. Fever is due to a disturbance of these centers, so that more heat is produced than normal and proportionately less thrown off. Let it be supposed that a man is placed in such atmosphere that he is unable to get rid of the heat which he is forming. The temperature of the body will slowly rise, and he will suffer from a general thermic fever. If early or late in this condition the inhibitory heat-center becomes exhausted by the efforts which it is making to control the formation of heat, or becomes paralyzed by the direct action of the excessive temperature already reached, then suddenly all tissues will begin to form heat with the utmost rapidity; the body-temperature rises with a bound, and the man drops over with one of the forms of coup-de-soleil." "Heat-

exhaustion," on the other hand, "with lowered temperature represents a vasomotor palsy—*i. e.*, a condition in which the existence of the heat paralyzes the center in the medulla oblongata, and the heat is dissipated more rapidly than it is produced."

Faintness in different degrees, with pallor, cool skin, feeble pulse, and, in bad cases, fatal syncope, are the symptoms of heat-exhaustion. This condition sometimes is succeeded by that with high temperature, or veritable sunstroke. The symptoms of heat-stroke in addition to high temperature are unconsciousness, stertor, dryness of the mouth and skin, anuria, frequency and irregularity of pulse, increased frequency, and later slowing and loss of rhythm in breathing (Cheyne-Stokes type); more rarely, vomiting and diarrhea. The temperature attained may be anything from 102° F. to 110° F. (38.8° C. to 43.2° C.), increasing in unfavorable cases as the fatal issue is approached, reaching its maximum postmortem at 110° to 113° F. (43.2° to 44.9° C.).

PROPHYLACTIC TREATMENT

Much may be done by those exposed to high temperature to avoid the grave symptoms so often incident to it. It is needless to say that heavy woolen, dark-hued clothing should be discarded, although what is worn next the skin should be wool. To this end military authorities have of late years made vast improvements in clothing soldiers, among whom, especially when on the march, sunstroke has been a frequent event. Instead of the heavy cloth suits formerly worn, linen and like textures are worn during the heated season. The sailor has never been as much hampered by clothing as the soldier. Drills in hot weather should be few and short. Halts should be frequent. Meals should be light and frequent, and an abundance of cool water and cool bathing allowed.

Of those engaged in other occupations, wherever they are exposed to high heat, such as engine-room workers, factory hands, carters, and hay-makers, it is needless to say that they should wear a minimum of clothing. If possible, cloths wet with cold water should be placed on the head and kept in place by the cap or hat. An abundance of water should be supplied for drinking purposes, as perspiration is thus favored, and it is well known that free perspiration tends to avert the dangers of sunstroke. On the other hand, alcoholic beverages should be prohibited to all laborers exposed to high temperatures, as it is well known not only that alcoholics bear high temperatures badly, but also that the temporary effect of alcohol on those thus exposed is most harmful. The prognosis in these cases is also much more unfavorable.

It is needless to say that good ventilation and a free circulation of air about the workman helps to keep him cool. In certain occupations where men are exposed to very high temperatures the day and night should be divided into short periods of a few hours, occupied by different shifts of workmen. This is especially the case with

the stokers of steamships, whose occupation is perhaps the most trying.

CURATIVE TREATMENT

Elevation of temperature being the primary cause of disturbance, efforts should at once be made to reduce it. Where the temperature does not exceed 102° F., it is usually sufficient to place the patient in a cool ward or room with an ice-bag to the head and to sponge the body continuously with ice-cold water until the temperature approaches normal. A cool tub-bath at 70° F. may be necessary to hasten the desired effect of returning consciousness and normal function. Cardiac weakness, as determined by cardiac action and pulse, may be treated with aromatic spirit of ammonia, brandy, or whisky, while a hypodermic injection of strychnin may be used where these remedies are slow of effect. Of 32 cases filling these conditions and thus treated at the Pennsylvania Hospital in July, 1901, all recovered. Where the temperature is higher, say 102° to 106° F., and does not fall rapidly, the patient should be submerged in a bath of cold water at a temperature of 70° F., further reduced by the addition of an abundance of ice. At the same time the patient should be rubbed with ice; ice should be continuously applied to the head, while ice-water may also be poured on the head. If it is impossible to submerge the patient in a bath, he should be placed on a cold slab of marble or a table and the affusions of cold water and frictions with ice continued. This should be kept up until the temperature falls to almost normal, or as long as the patient lives, temperature being taken from time to time in the rectum. Simultaneously with the reduction in temperature consciousness commonly returns, sometimes quite rapidly in the course of ten to fifteen minutes, but usually slowly, twenty-four hours sometimes elapsing before consciousness is complete, after which recovery is usually rapid. In these cases, also, stimulants should be given under the same conditions. Of 22 cases falling in this category at the Pennsylvania Hospital, total in 1901, all recovered.

In cases with temperature above 106° F. efforts should be redoubled, cold being applied in all possible ways. The patient should be placed, if possible, in a tent in the open air, but in the shade, while water should be sprinkled over it and electric fans should be kept playing. Iced water should be injected into the rectum. In these severe cases, too, salt solution should be used by hypodermoclysis, or preferably by intravenous injection, with a view to more prompt results—for two purposes: for sustaining the heart and diluting toxic substances which may have arisen in the blood. Venesection should, however, precede, or be practised simultaneously with, intravenous injection, as it is desirable to empty the vessels of hot, toxin-charged blood before replacing it by the cooler salt solution, which should not be above blood heat.

Of 15 cases with temperature 106° to 108° F., in the summer of 1901, at the Pennsylvania Hospital, 3 died—a mortality of 21.4 per cent. Of 22 cases whose temperature exceeded 108° F., 9 died—a mortality of 40.9 per cent. Of the 36 very severe cases last referred to, 12, or $33\frac{1}{3}$ per cent., perished.

With the fall in temperature delirium occasionally develops, or there may be a secondary rise in temperature, commonly easily controlled by cool sponging.

Succeeding improvement in the graver cases sometimes is met a condition of mental imbecility, as evidenced by incapacity for sustained mental effort, while exposure to moderate high temperature quickly excites headache, vertigo, and even great mental excitement. So, too, persons who have recovered from the graver symptoms of sunstroke are sometimes subject to epileptoid convulsions. In these cases there may be permanent meningeal, spinomeningeal, or central nervous lesions. Such cases should be removed to a colder climate.

DISEASES OF THE BLOOD

By Richard C. Cabot, M.D.

PERNICIOUS ANEMIA

Definition.—Among the anemias whose course is grave, perhaps fatal, it seems to me convenient to distinguish as *pernicious anemia* the group of cases whose cause is unknown, and to exclude from this category all cases of whose etiology we have any definite knowledge.

(*a*) *Parasitic Anemia.*—Cases of equal severity and sometimes with identical symptoms may be produced by any of several species of intestinal parasites—the old-world hook-worm (Ankylostoma duodenale), the new-world hook-worm (Uncinaria Americana), the Dibothriocephalus latus, and probably some others. But these cases I shall call *parasitic anemia*, the diagnosis depending on the presence of the worms or their eggs in the feces.

(*b*) *Anemia from Sepsis.*—Cases of progressive anemia developing after child-birth are often mentioned in the older writings on the subject, but are rarely heard of to-day. This is owing, I surmise, to the diminution in the amount of puerperal sepsis. Sepsis is capable of bringing about an acute fatal anemia, doubtless through hemolysis, and these cases may present clinically most of the features of the cryptogenetic cases here called "pernicious," from which, however, they are distinguished by the evidence of sepsis. I recently followed a case of this type which presented all the signs of pernicious anemia (after child-birth) except that a marked leukocytosis was present throughout. Postmortem we found a diphtheric endometritis, which had given during life no signs of its presence. Similar cases often run their course with the features of septic endocarditis. Occasionally this type of anemia occurs in pregnancy as a manifestation of toxemia parallel to vomiting or eclampsia.

(*c*) *Hemorrhage* from piles may go on for years unknown to the patient, and produce a grave anemia. Morse has reported a case of this type in which the blood was for a time identical with that of pernicious anemia, as above defined. The distinction in such cases depends on the discovery of the hemorrhages.

(*d*) *Aplastic anemia* is a term applied to a group of fatal anemias occurring mostly in young people, especially in girls, and characterized by repeated small hemorrhages (which are symptomatic and not sufficient in themselves to produce the anemia), together with changes in the blood which differ from those of pernicious anemia by the absence of nucleated red cells, the much greater diminution in the granular leukocytes, and the smaller size of the red cells ("mi-

crocytic anemia"). Postmortem the marrow shows no regenerative changes, and is in this respect sharply differentiated from the vast majority of cases of pernicious anemia as defined in this article.

Nature and Course of the Disease.—(*a*) Excluding all these cases and, of course, the more obviously symptomatic anemias dependent on malaria, syphilis, or malignant disease, we have left a large group of cases regarding whose etiology we have no certain knowledge. These cases occur usually in persons past middle life, and not infrequently in more than one member of a single family. I have followed cases in two brothers in one family and in a brother and sister in another.

The anemia is not the cause of all the symptoms in this disease, but is itself a result of the same (unknown) poison which produces the lesions of the spinal cord. The nature of these lesions and the similarity between the blood-changes and those produced by the presumably toxic influence of the Dibothriocephalus latus in the intestine incline us to believe that pernicious anemia is itself due to an autointoxication, perhaps of intestinal origin. But there is no definite knowledge upon this point.

(*b*) The *course* of the disease is characterized by a series of exacerbations and remissions. At the acme of a remission the patient may present every sign of perfect health, and his blood may be in perfect condition so far as our present methods of examination enable us to discover. During an exacerbation the patient is often given up for lost; he may remain unconscious, speechless, and almost pulseless for days, and yet within a couple of months may be on his feet again, apparently well. Even when the red cells have fallen to 142,000 (as in Quincke's often quoted case), the patient may regain his strength and color for a time.

Within two or at most three years, however, the last remission is usually passed, the patient sinks into coma and dies.

Recovery is almost, but not quite, unknown. Among 1200 cases of which I have notes, there are 5 whom I know to be alive four years after the time when the diagnosis was established. Two of these seem really to have got upon their feet for good, while the others appear to be still in a precarious condition. Many recoveries are reported from time to time in medical journals, but almost all of them on evidence that is wholly insufficient.

In the absence of any clear and certain knowledge regarding the nature of the poison which again and again decimates the red corpuscles and disintegrates the nerve-cells of the spinal cord, we cannot at present hope to accomplish more than to prolong the spontaneous remissions which are so characteristic of the natural course of the disease. Cases apparently get well, perhaps 1 in 500, but there is no reason to believe that our treatment is responsible for the result.

Indications for Treatment.—*Etiologic Treatment.*—(*a*) W. Hunter * has advocated and carried out a plan of treatment based on the

* "Pernicious Anemia," London, 1902.

hypothesis that the disease is an intestinal autointoxication. He advises farinaceous diet and a course of drugs designed to limit intestinal fermentation: betanaphthol, calomel, etc. No one but Hunter himself, however, has reported any considerable success with this plan of treatment, and many have failed to obtain any good results with it. I have never seen it of the slightest avail.

(*b*) It has seemed to me that some cases have been benefited by treatment designed to produce a moderate diarrhea for a considerable period. I have several times known the condition of the patient's blood to improve rapidly after the cessation of a spontaneous and very intractable diarrhea, and independent of any treatment whatever. In one case I persuaded the patient to take sufficient doses of the fluidextract of cascara sagrada to produce at least two watery discharges a day. Improvement followed, and the patient has now been free from symptoms for nearly a year. I am still experimenting with this treatment, and am by no means sure of its value, but it seems to me to have enough in its favor to deserve a wider trial in cases which are obviously running down under other methods of treatment.

(*c*) It has appeared to me that many cases of pernicious anemia are considerably better in the warm outdoor months (summer) than in the winter months which confine them to the house. The end of the winter and the early spring is the period when most cases are at their worst, and when the weather begins to permit a larger number of hours in the open air, temporary improvement often occurs.

I have also noticed that some patients improved on moving from the city to the country. These facts, if they are such, suggest the propriety of advising our patients to spend as many hours as possible at rest in the open air, adopting, in fact, the habits of the phthisical patient, as can be done with profit in so many other diseases. If the climate of the patient's home is too severe to permit him to be much out-of-doors and in the sunshine for several months in the year, it is well to consider the advisability of his moving to a warmer climate. We must not fail, however, to take account of the depressing mental effort of absence from home and friends, for the patient is by no means insensible to these influences, and his health may be greatly injured by homesickness and ennui.

Symptomatic Treatment.—Although we have every reason to believe that the bone-marrow is in a state of hyperactivity, we do our best, for empirical reasons, still further to stimulate it by the use of *arsenic*, and thereby to overcome one of the most prominent symptoms of the disease—anemia.

Of course, we cannot in this way reach the *cause* of the anemia or of the other symptoms of the disease, and in many cases it is obvious that we do not even palliate the symptom. Indeed, there are few questions in therapeutics on which it is more difficult to arrive at a reasonable conclusion than this: Is arsenic of value in pernicious anemia?

That many cases improve after its use is indubitable, but how are we to know that such improvement is not due to one of the spontaneous waves of amelioration which are so characteristic of the disease? If the arsenic were really the cause of the improvement, why does it fail altogether to arrest the subsequent decline? I have seen so many cases fail altogether to improve under its use that I cannot feel at all certain of its efficacy in the cases which I have seen improve during its exhibition.

Again and again I have seen patients lose ground while taking arsenic, give up the drug, and later improve without any medicament whatever. On the other hand, I have seen marked and rapid gain under its use, and I cannot altogether disregard the weight of opinion in its favor among competent internists the world over, even though the evidence on which these opinions are based is not very tangible or convincing. Personally I always give the drug unless the stomach is extremely irritable, and even then I have known improvement in all symptoms (including the stomach symptoms) to follow its use.

It seems to me most convenient to give it in the form of Fowler's solution, beginning with 2 drops three times a day after meals, and increasing 1 drop daily until 15 drops are taken at each dose, provided that, in the mean time, no toxic symptoms attributable to the use of the drug have made their appearance. Such symptoms are, especially, nausea and itching, burning, or swelling of the eyes. After reaching a 15-drop dose, it is well to continue a few days without changing the amount of the drug given, and then, if no ill effects have appeared, I am in the habit of gradually increasing the dose as before until 20 drops are taken after each meal. I have never gone above this figure, though I have no reason to believe that it would be unsafe to do so. After continuing for a week at 60 drops a day, the patient is advised to discontinue the drug altogether for a week and then to begin again, this time with a 10-drop dose, and work up as before.

It is worth realizing how rapidly a patient may improve even without any drug treatment at all, in order that we may not attribute any undue efficacy to our drugs. In cases receiving no treatment except good food and air I have known the red cells to increase from 1,800,000 to 5,200,000 in fourteen days. In other cases they rose from 2,200,000 to 4,000,000 in thirteen days, and from 1,500,000 to 3,200,000 in twelve days, the patient almost "rising from the dead" during the same period. Yet such splendid gains as these do not in any way insure the patient against an equally speedy decline, which drugs are as powerless to prevent as they were to produce the previous improvement.

Bone-marrow, iron, oxygen, transfusion of blood, and infusion of artificial serum are, in my opinion, useless or deleterious. Improvement may coincide with their use, but there is no evidence that they are the efficient cause.

The *digestion* of patients suffering from pernicious anemia is,

on the whole, surprisingly good, especially when we realize that their gastric contents scarcely ever contain free hydrochloric acid. Indeed, the absence of free HCl is a much more constant sign in pernicious anemia than in gastric cancer, as Stockton and others have shown. Nevertheless, disturbances of digestion are usually slight or altogether absent during most of the course of the great majority of cases.

Periods of diarrhea and vomiting occur occasionally and run their course without being greatly influenced by anything that is done for them. Indeed, I regard it as very questionable whether it is ever wise to attempt to check a diarrhea in pernicious anemia. I have so frequently seen great improvement follow its occurrence that it seems to me quite possible that, like hemorrhage occurring in uremia, it has a therapeutic function which we should aid, rather than attempt to thwart. I say "attempt to thwart," for in my experience treatment has often been wholly unavailing in the majority of cases.

Equally remarkable, in view of the almost constant finding of extreme fatty degeneration in the heart postmortem, is the absence of severe circulatory symptoms. Moderate dyspnea and slight edema of the feet are the rule, but they disturb the patient very little and are not influenced by any treatment, except such as succeeds in improving the corpuscular richness of the blood.

Massage can bring into the peripheral circulation a larger number of red corpuscles than are usually present there, and so increase *temporarily* the number of cells in a cubic millimeter of peripheral blood, but there is no reason for supposing that the patient is benefited by the change.

The diet should be adjusted to the digestive power of the individual. His tastes and sensations should be consulted with the ultimate object of keeping him as near his normal diet (in health) as his condition will permit. There are no good grounds for a *qualitative* limitation of his food in any direction, and the quantity should be adjusted to the power of digestion and assimilation. Most patients can take solids as well as liquids, and are not apt to be distressed by any particular kind of food.

Exercise is not important. Air—fresh air—is important, and even when the patient is confined to bed, we should make every effort to provide him with free access to oxygen by putting his bed near an open window, or, if possible, out-of-doors. In the remissions the patient's own spontaneous desire for exercise is a sufficient guide to the amount suitable for him.

For the spinal degenerations, which may present no symptoms or may produce any grade of paralysis up to a total bed-ridden helplessness, we have practically no treatment.

Reëducation of the muscles can rarely be carried out, as the patient cannot bear the necessary labor. There is rarely any considerable atrophy, hence massage and electricity have no application. In late stages the sphincters may become relaxed, and most careful

nursing is necessary to prevent the formation of bed-sores. To keep the patient and the bed dry and clean, and to relieve pressure on bony prominences (sacrum, trochanters, heels) by means of rings of cotton or inflated rubber, are the main indications.

PARASITIC ANEMIA

Among the intestinal parasites capable of exciting a more or less serious anemia there are but two which have been thoroughly studied:

1. *The hook-worm:* (*a*) Ankylostoma duodenale. (*b*) Uncinaria Americana.

2. *The fish tape-worm* (Dibothriocephalus latus).

There is reason for believing that all these parasites produce anemia not so much by sucking blood, as by developing a poison which the infected individual absorbs—a poison which destroys the red cells.

Not every person whose intestine contains these parasites becomes anemic. Indeed, in some they seem to be quite harmless, while in a majority, probably, of all infected cases the symptoms and the anemia are mild and escape notice. But when a large percentage of the population is infected, as in our southern states and certain parts of Porto Rico, there are many cases of intense anemia which hang along for months or years and finally die.

Treatment.—Treatment is directed to: (*a*) The prevention of the disease. (*b*) Its cure by anthelmintic drugs.

(*a*) The avoidance of fish suspected to be infected, and the more thorough cooking of all fish, will doubtless diminish the number of tape-worm infections; also the more thorough destruction of human fecal matter through the more general use of water-closets or earth-closets.

Hook-worm infection is now generally believed to gain entrance through the skin. An itching dermatitis ("ground itch") is produced on the feet of individuals who habitually go barefooted by the entrance of the hook-worm larvæ with which the soil of certain districts is saturated.

Prevention lies in the direction of changing the habits of the people. The feet must be protected, and the habit of depositing feces—and with them hook-worm eggs—anywhere and everywhere must be checked.

Cure of the disease can be obtained by the use of betanaphthol, thymol, or male-fern. Betanaphthol, first recommended by Bentley,* is considered by Ashford and King† as "bidding fair to eclipse thymol and male-fern," the drugs hitherto most employed.

The mode of administration is as follows: 30 grams (an ounce)

*Indian Medical Gazette, Calcutta, April, 1904.

†Report on Anemia in Porto Rico, Dec., 1904: Bureau of Printing and Supplies, San Juan, P. R.

of sodium sulphate is given in the evening. Next morning the patient is kept in bed and given no food until 1 P. M. During the morning two doses of betanaphthol (1 gram each) are given,—one at 8 A. M., one at 10,—while at 12 another 30 grams of sodium sulphate is administered. Some dizziness follows the drug, but in other respects it appears "ideal, so far as a vermifuge may be."

Thymol is given in the same manner, except that the dose is twice as large.

The vermifuge is given once a week as long as ova remain in the feces. In about 40 per cent. of cases one dose suffices (Ashford and King).

Iron in the form of Blaud's pills has perhaps a slight effect in quickening convalescence in severe cases, but many do just as well without it.

CHLOROSIS

Definition.—The substance of our knowledge of the pathogenesis of this disease seems to me admirably summed up in the statement of Ewing:* "Chlorosis results from a functional insufficiency of the bone-marrow produced in congenitally predisposed subjects by a series of conditions most often combined in young women at, or rather soon after, 'puberty.'" The "series of conditions" here referred to is, in the first place, the vast change in temperament, outlook, and experience to which the woman at the chlorotic age (seventeen to twenty-four) has more or less painfully to adapt herself. Secondly, the recurring and sometimes excessive losses of blood by menstruation, and, thirdly, the lack of iron in the food—a point on which Stockman has laid great—I think undue—stress.†

If untreated, the disease lingers on indefinitely and may come to a standstill in a morass of chronic invalidism, or may drag down the patient to a precarious state not unlike that of severe pernicious cases. The possibility of death from thrombosis of the cerebral sinuses is not to be forgotten. Nevertheless, we are hardly ever able to study the natural history of the disease untreated, because in this part of the world treatment is administered before many months in practically every case, either by physician, by friends, or by the patient herself, and death from chlorosis is very rare.

Our function, therefore, is not to save life, but to prevent or cut short invalidism by stimulating the blood-making functions to renewed activity and keeping up treatment until the danger of relapse has passed by.

Indications for Treatment.—We have today a true specific medication for only six diseases—malaria, syphilis, diphtheria, epidemic meningitis, myxedema, and chlorosis. Iron is as much a specific for

* Ewing, Clinical Pathology of the Blood, 1903, second edition, p. 193.

† Reasoning backward from the good effects produced by giving iron in chlorosis, we can easily persuade ourselves that lack of iron in the food must have produced the disease, but the diet of girls of this age is not radically different from that of other persons who do not become chlorotic.

chlorosis as quinin is for malaria. There are rare, stubborn cases of chlorosis, as there are of malaria,—cases resisting the specific treatment,—but the law is not upset thereby.

How the iron acts is a much more difficult problem, and one that I do not intend here to discuss.

Iron is best given, in the vast majority of cases, in the form of Blaud's pill. The organic preparations such as ferratin are sometimes more effective in patients who prefer expensive drugs. In others they have no advantage. It is very rare to find a patient who cannot take Blaud's pill. Some other forms of iron, notably that abominable preparation the tincture of the chlorid, disturb the stomach, produce constipation, and attack the teeth, but I have never known any troubles which could reasonably be referred to the agency of Blaud's pill, and we rarely hear of any complaint of gastric irritation from it. Not infrequently I have found that Blaud's pill was the only laxative needed in chlorotic cases that had been troubled with constipation.

A 5-grain pill after each meal, increased in a week to double or occasionally triple that dose, usually produces marked improvement by the second or third week, but, as a rule, it takes several months to get the hemoglobin up to normal.

In the rare cases which resist the action of Blaud's pill or in which it proves irritating I usually try next reduced iron—1 to 3 grains twice or thrice daily in pill form.

Occasionally Fowler's solution, given in the manner described on p. 818, is of value as a stimulant to hemogenesis.

The citrate of iron can be given hypodermically with very little pain, and with no danger of abscess if a sterile syringe and a sterile platinum needle are used. The sterile iron solution is sealed up in glass capsules with tapering ends, which can be broken off when we are ready to use it. The injection need not be given especially deep.

Empirically it has been found that severe and obstinate cases of chlorosis often do better if they are put to bed and kept there for some weeks during the administration of the iron. Mild cases—which make up nine-tenths of those one sees in general practice—need not go to bed.

Bleeding as a treatment for chlorosis is rarely employed, because other and less heroic measures suffice; yet there are good reasons theoretically why it should be efficacious, and there is a certain amount of clinical evidence in its favor. Bleeding should serve to stimulate hemogenetic function and multiply the number of nucleated red cells in the marrow, as it does in ordinary traumatic hemorrhage. Further, the blood-vessels are overfilled, as Haldane and Smith seem to have shown ("serous plethora"), and some relief might be afforded by tapping one of them. Personally, I have no experience with this method of treatment.

Certain symptoms which often need treatment must next be mentioned:

(*a*) Hyperchlorhydria.
(*b*) Constipation.
(*c*) Insomnia.

In some cases these minor effects of the anemia disappear without any treatment beyond the administration of iron, as above described. In others we have to combat them directly.

For *hyperchlorhydria* I advise six small meals daily, containing an abundance of carbohydrates and fats, and little proteid food except a moderate amount of milk.

For *constipation* nothing is better than the solid extract of cascara sagrada in 1- to 3-grain doses once or twice daily.

For *insomnia* we should try first the effect of long days at rest in the open air, a warm bath at bed-time, or perhaps gentle massage at the same hour. An occasional dose of trional (7 grains) may be used, but neither this nor any other drug should be used continuously.

LEUKEMIA

Definition.—A hyperplasia or hyperactivity of certain leukocyte-forming tissues, chiefly in the bone-marrow, which results in flooding the blood with some or all of the cells normally formed and retained in those tissues, and in restricting the area of red-cell production in the marrow, so that anemia results. The disease is probably akin to the neoplasms, but we are quite ignorant of the conditions which permit the flooding of the blood-current in leukemic cases and prevent such flooding in pseudoleukemia.

Course.—The natural course of the disease is to death within a period varying from a few days or weeks to several years. There is no satisfactory evidence to show that any case has ever been cured. The whole process may run its course with fulminating activity and kill in a week, or life may be prolonged for several years. A latent period, of whose duration we know little or nothing, certainly precedes the development of active symptoms in many cases whose nature is accidentally discovered in the course of a routine examination—*e. g.*, for life insurance. Remissions in the symptoms, with return of the blood to normal, occasionally occur. More often, after an intercurrent infection, the blood improves, but the patient continues to go downhill.

The differentiation of the two forms of the malady, myelogenous and lymphatic, has no bearing on the treatment, which attempts, by the same methods in all cases, to prolong life and delay the progress of the disease.

Treatment.—The most hopeful therapeutic resources at our command today are: (*a*) The use of the *x*-ray. (*b*) The use of arsenic.

The number of cases which have shown distinct improvement under *x*-ray treatment since Senn's original suggestion in 1903 is now considerable, and while it is *possible* that suggestion has played

a part in bringing about the improvement, it does not seem to me *likely*.

The improvement in the cases above referred to have been in part symptomatic, in part objective. Some cases have shown a remarkable change in the blood-picture—a return nearly, or quite, to normal, with great diminution in the size of the spleen. The duration of the improvement in the cases so far reported is not great enough to warrant us in supposing that we have in x-ray treatment a cure for even the mildest cases of leukemia. To delay the course of the disease—sometimes for several years—is the best we can do.

Moreover, the application of this treatment is already seen to have decided limitations. In acute cases it is apparently worse than useless. In lymphatic cases far less improvement has been reported than in myelogenous; the latter are the most hopeful. Burns of greater or less severity have in many cases compelled a suspension of the treatment. Lastly, several of the most favorable cases, after showing apparently very decided improvement, objective and symptomatic, have suddenly and without warning died.

Nevertheless, the results thus far obtained are, I think, sufficient to warrant one in saying that no other therapeutic agent has ever done so much good in leukemia cases as has been accomplished by the x-ray.

In most cases the x-ray has been applied over the spleen and long bones, the exposure lasting from five to fifteen minutes, and being repeated twice or thrice a week, or in some cases every day. If indications of a burn appear (or in some cases as a matter of routine), the rays are applied over the long bones, though how much activity penetrates to the marrow is doubtful.

Animal experiment shows that the x-rays have a specific destructive activity on lymphatic tissue—and on the generative organs, —indeed, that the spleen and lymph-glands can be almost abolished by exposing the whole animal to the rays. The good results of the treatment are therefore due presumably to the destruction of leukocytic and leukoblastic tissues—and to the opportunity for red cell regeneration thus provided.

In lymphatic cases the enlarged glands—and the spleen too—are to be exposed to the rays.

Arsenic.—Previous to the employment of the treatment just described, the mainstay of our therapeutics in leukemia has been *arsenic.* Following its use in the manner already described above (see p. 818) many cases have shown improvement in the anemia which accompanies the later stages of most cases. Possibly this stimulus to the formation of red cells is the only benefit produced by arsenic, but it is a fact that the number of white cells has sometimes greatly diminished during the use of the drug. This is, however, not so significant as it would be if it was not the custom to employ arsenic in all cases of leukemia and from the first.

Prominent symptoms other than the anemia which sometimes

need treatment are: (*a*) Hemorrhage. (*b*) Diarrhea or constipation. (*c*) Pain and dragging sensations from the enlarged spleen.

Nosebleed is sometimes so severe that plugging with gauze has to be resorted to. Hemostatic drugs are not so effective. Diarrhea is sometimes very intractable. Diet seems to have no considerable effect. The pill of camphor, opium, and tannin (each, 1 grain) is likely to be as effective as any agent yet known.

Constipation is to be treated in the ordinary ways, *e. g.*, by exercise, if the patient can take it, by massage and low-proteid diet if he cannot, by cascara sagrada and enemata if other measures fail.

The discomfort due to the weight of the spleen may be somewhat relieved by a suitable abdominal bandage.

PURPURA

It may be safely said that there is no such disease as purpura. Subcutaneous, submucous, or subserous hemorrhages of greater or less extent occur in many infectious diseases, some of which are known and named (variola, measles), many of which are still labeled only by their most prominent symptoms—purpura or arthritis. Similar hemorrhages occur in various disturbances of metabolism—scurvy, cancerous cachexia, or as a result of drugs (potassium iodid, sodic salicylate, and others), but there is no rational or structural tie connecting these loose groups of facts, and no possibility of distinguishing any well-knit disease-entity among them.

In the mild cases the hemorrhages need no treatment, and our attention is directed to combating the scurvy, the drug-poisoning, or whatever other cause is at work.

In the severe or fulminating cases ("purpura hæmorrhagica") the direct transfusion of blood sometimes saves life. There is no good evidence that any drug taken by mouth or subcutaneously has any appreciable effect upon the bleeding, and hemostatic drugs are usually inferior to direct mechanical means.

HEMOPHILIA

A congenital tendency to bleed after very slight traumatism. The cause is wholly unknown, but usually leads to an uncontrollable hemorrhage before puberty.

Direct transfusion may be brilliantly successful. If this cannot be done treatment consists in avoiding every occasion for hemorrhage that foresight can predict (circumcision, extraction of teeth, pocket-knives, etc.), and in the effort to control the bleeding when it occurs by the ordinary, but usually unavailing, surgical measures—gauze and pressure.

DISEASES OF THE LYMPHATIC SYSTEM

By George Dock, M.D.

LYMPHADENITIS

Inflammation of lymphatic glands is usually due to infectious material that has passed centripetally from a focus of disease in the area tributary to the inflamed gland or glands. It may also occur in the course of a blood infection, as in typhoid fever, tuberculosis, syphilis, pest, or anthrax. The peripheral focus may be very small, even impossible to find, as in many wound infections received at operations or autopsies. Lymphadenitis also follows strains sometimes, in which case it may be supposed the traumatism was a predisposing cause only, the exciting cause being a hematogenic infection.

Lymphadenitis is characterized by the ordinary symptoms of inflammation—swelling, pain, with fever and other symptoms of infection and intoxication. It may be acute or chronic, the latter often being due to repeated infections, as in the enlarged glands in the neck associated with disease of the nose and pharynx, and those associated with some chronic skin diseases.

The course usually tends to resolution, but in some severe infections the glands suppurate or undergo necrosis, leading to periadenitis, phlegmon, or, under certain circumstances, to the formation of sinuses or ulcers, with specific characters in some cases—tuberculosis, syphilis.

Treatment.—Treatment based upon etiologic factors can be applied in some forms of adenitis, as the tuberculous, syphilitic, or plague. In the majority of mild acute cases causal treatment is not applicable, but large doses (90 to 120 grains a day) of salicylates may be given with the view of checking the development of germs.

Symptomatic treatment is then in order, and usually includes rest of the affected part, often also general rest, and cold applications or topical dressings to relieve pain. The ice-bag is useful for the inflammatory process, as well as the pain, and often suffices, even in severe acute inflammations. Iodin, so often used externally, is of doubtful value, but the injection of ½ minim of pure carbolic acid into the part inflamed often aborts more severe forms, and should be resorted to if the signs indicate advance of the process.

General symptoms, such as pain, nausea, vomiting, or loss of appetite, should be treated as under other conditions. Constipation should always be treated. The possibility of general infec-

tion must be borne in mind, and careful observations made in order to detect it as early as possible. Leukocyte counts and blood-cultures are often useful aids.

The treatment of infected areas causing lymphadenitis is always indicated, but needs no further directions here.

In case the inflammation goes on to suppuration, surgical treatment is in order, and should not be postponed by lack of care in the observation of the local conditions. Of surgical measures that should be familiar to the general practitioner, the hyperemic methods of Bier may be mentioned.

Treatment based upon the history is very often indicated by the evidence of a chronic anemia, an important predisposing cause of lymphatic diseases. If possible, the cause of the anemia should be sought out and removed, and the anemia should be treated upon lines indicated in the sections upon that subject.

LYMPHANGITIS

Inflammation of lymph-vessels is due to causes similar to those concerned in lymphadenitis. Like the latter, the primary focus may be distant or impossible to discover. If the large trunks are affected, there are pain and swelling, involving the vessels and usually the adjacent tissue. The skin over the vessel is often red and swollen. When smaller vessels are affected, the area may be round, irregular, or long, sometimes radiating or triangular. On account of the histologic relations of the small lymph-vessels, the process involves the surrounding tissues, so that cellulitis or dermatitis is sooner or later associated with the lymphangitis, as we see in erysipelas.

The process may be acute or chronic, depending upon the cause of the disease.

Besides the objective symptoms of swelling and redness, often associated with vesiculation, suppuration, or hemorrhage, there are the symptoms of an acute intoxication, such as fever, malaise, sometimes chills, pains in muscles or bones, anorexia, nausea, and vomiting.

The course is generally favorable, ending in resolution; but suppuration, lymphadenitis, abscess, ulcers, or septicopyemia may follow, with their respective dangers.

Treatment.—The symptomatic treatment is usually the only one applicable. Rest, treatment of infected foci, ice-compresses, the external application of ichthyol (1 : 4 of vaselin or water) should be used, and surgical treatment be applied as soon as complications are discovered. In chronic cases hyperemia or counterirritation, pressure by bandages, and massage should be used, due care being given to the treatment of remnants of infection.

LYMPHANGIECTASIS

Owing to the free anastomosis of lymph-vessels, results of obstruction are rarely seen. Dilatation sometimes occurs from re-

peated or protracted inflammation, prolonged obstruction, as in some forms of edema, removal of lymph-glands, or in elephantiasis. It is sometimes congenital in local processes, like macrocheilia and macroglossia. The upper and anterior part of the thigh is sometimes the seat of a lymphangiectasis in which perforation occurs, permitting the formation of lymph-fistula.

Treatment.—The medical treatment of these affections is useless. In some cases surgical treatment is highly satisfactory.

LYMPHANGIOMA

Lymphangioma is a tumor-like formation of cavernous structure, composed principally of lymph-vessels or sometimes a cystic tumor. It often occurs as small tumors in internal organs, having no clinical importance. Sometimes these cysts occur in the skin, usually congenital, causing more or less deformity. A tendency to sarcoma seems strongly inherent in these tumors.

The treatment is surgical.

STATUS LYMPHATICUS—LYMPHATISM

Status lymphaticus, or the lymphatic constitution, is a condition in which there is enlargement or hyperplasia of the lymphatic apparatus. It occurs both in children and in adults. In children it is often associated with rickets. In adults or older children there is sometimes hypoplasia of the heart and blood-vessels. The hyperplasia most frequently affects the thymus, then the tonsils and other lymphatic tissue in the pharynx, and that in the walls of the intestinal canal. Superficial glands are rarely enlarged. The spleen is often enlarged; the bone-marrow is red in some cases, though this may be secondary to anemia.

Status lymphaticus is important on account of its relation to sudden death. This may occur from trifling causes, or even where no cause can be discovered. Sometimes the subjects are found dead in bed. In other cases death has followed a bath, an anesthetic, the injection of antidiphtheric serum, or has occurred from insignificant exertion in convalescence from infectious disease.

The subjects cannot always be recognized during life, but the condition should be suspected in persons of chlorotic type, sometimes fat, but rarely strong, with enlarged tonsils or adenoids, a history of spasm of the glottis, evidences of rickets and enlarged spleen. Sometimes the mesenteric glands are enlarged. If enlargement of the thymus can be demonstrated, as by Roentgen rays or percussion, the diagnosis is nearly complete. The blood has not been sufficiently examined, but there is probably always anemia, and perhaps increase of lymphocytes in the blood (Ewing). The greatest danger of the disease is from sudden death, as stated above, with cardiac, respiratory, or toxic symptoms. In rare cases the cause of

death is mechanical, the enlarged thymus compressing the trachea. For others, the most plausible explanation is that of George Blumer,* who suggests that the disease is associated with an intermittent lymphotoxemia.

Treatment.—According to the prevalent conceptions of the disease, no direct treatment can be applied. All the measures that improve health and harden the constitution should be used, such as careful attention to diet, open-air life, proper exercise, bathing, and the avoidance of all unhealthful habits. Enlarged tonsils or adenoids should be removed, with due regard to the dangers of the operations. Such symptoms as anemia, poor digestion, constipation, or any others that may occur should be carefully treated. Special efforts should be made to escape the acute infectious diseases. The thymus may be treated with Roentgen rays, or may be removed by surgical methods.

HODGKIN'S DISEASE

The term Hodgkin's disease, loosely applied in the past, is accepted as the convenient name for a condition characterized clinically by progressive enlargement of the lymph-nodes, with progressive anemia, and anatomically by a peculiar hyperplasia of the affected nodes. Its etiology is unknown. It is more common in men than in women, and in young adults, but has been encountered in all ages. The enlarged nodes simulate certain tumors closely, but the swelling, as a rule, does not invade the capsule, nor produce metastases. Bacteriologic studies have been contradictory, and the reported finding of spirochetes has not been confirmed.

The disease begins by the enlargement of lymphatic glands, usually in the neck, later appearing in the axillæ, inguinal regions, thorax, mesentery, and retroperitoneal regions. The masses vary much in size and are sometimes enormous; the individual nodes are smooth, almost never confluent. They are of varying consistency; sometimes so soft as to seem fluctuating, sometimes very hard, but usually between those extremes. The histologic feature is a peculiar hyperplasia of the germinal centers of the nodes, with increase of blood-vessels and proliferation of endothelium, the normal structure soon becoming lost. There are mononuclear cells of all sizes, polymorphonuclear, mast, giant, and often increased numbers of eosinophile cells in the affected nodes. Hyperplasia of lymph tissue occurs in various organs, especially the spleen, liver, and kidneys. Tuberculosis is sometimes associated, and has been thought to be the cause, but this view is now abandoned.

The disease begins insidiously, the enlarged glands being discovered before other symptoms have been noticed. Symptoms are sometimes caused by pressure of the masses—dyspnea, pain in the

* The Relation of the Status Lymphaticus to Sudden Death, Death under Anesthesia, and Infection, Johns Hopkins Hosp. Bull., 1903, xiv, 270.

arms, edema of the legs, sometimes jaundice. The later course is usually chronic, but may be acute. The anemia is of the secondary type, and may become extreme. The leukocytes are slightly increased; the differential count varies and is not characteristic. The eosinophile cells are sometimes relatively or absolutely increased, but rarely extremely so. Fever is a frequent symptom, usually of low remittent type, sometimes irregularly intermittent, sometimes recurrent. In some cases it can be traced to secondary infection, especially tuberculosis.

Hodgkin's disease is a favorite name for all kinds of glandular swellings that are not frankly tuberculous. This custom should be abandoned. The differential diagnosis of the various diseases that resemble it, however, is so uncertain that the only satisfactory method is the removal of one or more of the enlarged glands, which can be done easily and safely under local anesthesia, and an examination by one familiar with the subject. It is important not to lay too much stress upon a history of tuberculosis or upon a tuberculin reaction. The prognosis is bad, most cases ending fatally in a few months, or at most two or three years.

Treatment.—Early extirpation is theoretically proper, but in practice rarely possible. After many glands are involved removal should not be done except for the relief of pressure symptoms. Remarkable results sometimes follow the use of large doses of arsenic, but the results are not permanent. Roentgen rays are much more promising, as they sometimes effect an apparent cure, and often distinctly prolong life (see page 663). The best results are obtained in the early stages, so that no time should be lost in making a histologic diagnosis.

The combination with internal treatment by arsenic seems still better. The Roentgen rays should be used once or twice a week, for fifteen minutes, with a moderately hard tube. It is usually satisfactory to treat only one mass, although where there are several large masses all may be treated in turn. The action is leukocytic, and toxic symptoms are likely to follow too intense action of the rays. In the later stages this treatment is capable of serious harm. Symptomatic treatment is then advisable, and must vary according to the indications.

Diseases of the Spleen

The spleen is frequently affected in the course of diseases of other organs, especially those of the liver, stomach, and intestines, and in many infectious diseases. In such cases various changes, from congestion to chronic inflammation, with hyperplasia of various elements, takes place. None of these conditions need be the subject of local or special treatment.

INFARCT OF THE SPLEEN

Infarcts of the spleen also occur in consequence of other diseases, but demand brief consideration as a distinct condition. They occur frequently in the course of diseases of the heart or aorta, in consequence of the tearing loose of bits of vegetations or clots which lodge in the splenic vessels. They may be single or multiple. They vary in size from that of a pin's head to half or more of the volume of the spleen. They are wedge-shaped or irregularly conic, with the widest part under the capsule. Though usually anemic, they are sometimes hemorrhagic, especially if due to virulent infectious material. They at first cause prominences on the surface of the spleen, with cloudiness or even fibrinous exudate on the capsule, but later undergo degeneration, often producing more or less deformity. The capsular inflammations may result in thickening or adhesions. Splenic infarcts rarely produce symptoms that are recognized, but at times there are pain, tenderness, and friction over the spleen. If the existence of a disease capable of producing embolism is known, a diagnosis in such cases is easy.

In most cases no treatment other than that of the primary disease is necessary, with relief of pain by morphin and the ice-bag.

In others, the embolus is infectious, and leads to softening or suppuration, or the infarct may become infected secondarily, causing liquefaction-necrosis or abscess. If the foci are small, they may be absorbed without further complications. Larger abscesses set up reactive processes around them, may become adherent, and sometimes rupture.

Treatment.—The treatment of all these conditions is surgical, and surgical measures must be applied as soon as the suspicion of necrosis or abscess is entertained.

Thrombosis of splenic vessels occurs under conditions similar to those causing embolism, or from local disease of the vessels, and is not capable of direct treatment.

PERISPLENITIS

Perisplenitis, with circumscribed or diffuse thickening of the capsule, does not require treatment.

RUPTURE OF THE SPLEEN

Rupture of the spleen occasionally follows infarct or abscess. It may also occur from traumatism, as a fall or blow, in a normal or more especially in an enlarged spleen. In any disease leading to enlargement of the spleen, and especially in typhoid fever, malaria, recurrent fever, and leukemia, the accident is possible. In typhoid fever and malaria puncture of the spleen for diagnostic purposes has been followed by rupture. The rupture may affect only the

capsule, or may involve the splenic tissue to a greater or lesser extent, sometimes the whole thickness.

The symptoms depend largely on the character of the rupture. When this is superficial, recovery may take place without any suspicion of the lesion. In others there may be pain, collapse, with signs of internal hemorrhage and increase of dulness in the splenic region. The most important diagnostic features are the history of trauma in the splenic region and the signs of internal hemorrhage.

In case the condition can be recognized, the only treatment is surgical, and this should be undertaken as early as possible.

MOVABLE SPLEEN

Owing to its relatively loose attachments and its position close to the diaphragm, the spleen even normally has a limited range of movement. Diseases that affect the position of the diaphragm near the spleen alter the position of the spleen more or less. Among these diseases are: effusions or exudates in the pleura, pneumothorax, new-growths, deformity of the dorsal spinal column. Diseases of the peritoneum may also affect the position of the spleen. In such cases we may speak of dislocation of the spleen. This may occur from other causes, such as strains and traumatism.

In any position the spleen may be unusually movable, due to an abnormal length of the ligaments, and it is then spoken of as a movable or wandering spleen. Such a spleen may become fastened in a new position. It then becomes again a dislocated spleen. Dislocation also is favored by unusual length of the ligaments and by stretching or tearing ligaments originally normal. Also by increased weight of the organ, as in malaria and leukemia, although the conditions in the majority of cases of these diseases indicate that mere weight alone does not suffice to cause dislocation. The effect of strains is shown by the occurrence of the dislocation in confinement. The process may be sudden or slow, or may occur in a series of partial dislocations. Enteroptosis is often said to favor dislocation of the spleen, but if so, the relation does not seem to be very close.

The dislocated spleen may lie in any part of the abdomen, or even, in rare cases, as the result of accident or still more rarely as a congenital anomaly, outside of the abdomen or even outside of the peritoneum. The most frequent seat is just below the normal locality or in the left iliac fossa, but it may be in the mid-abdomen, the hypogastric region, the true pelvis, in a hernial sac in the inguinal region. The hilum may point in any direction. The splenic flexure of the colon fills the place previously occupied by the spleen. Corresponding to the previous condition, the dislocated spleen is usually large, but it may be normal or smaller than normal, as the result of contraction or lack of blood-supply. There is a tendency on the part of a dislocated spleen to become enlarged as the result of interference with the venous circulation. Greater obstruction, as from

twists of the vessels, may cause thrombosis or necrosis. The vessels may rupture and the spleen become free, and remain as a foreign body in the abdomen.

The dislocated spleen may lead to obstruction of the stomach or intestine, in the latter case with fatal ileus. Gangrene of the fundus of the stomach has been caused by a displaced spleen.

Wandering spleen may produce no symptoms. Sometimes there are pains, radiating or localized, either referred to the position occupied by the spleen or to a remote part, as the heart, shoulder, or thigh. Vague sensations of weight may be noticed. Indirect symptoms, due to pressure, may be present, such as nausea, vomiting, constipation, headache, disorders of sleep, amenorrhea or dysmenorrhea, frequent urination, pain or weakness of the legs. The pressure symptoms are likely to vary if the position of the spleen is altered either spontaneously or by art.

Treatment.—In case of acute dislocation of the spleen in which a diagnosis is made, an effort should be made to restore the organ to its natural position by posture and manipulation, followed by rest, and a suitable bandage.

In chronic cases, if the spleen is enlarged from a disease like malaria, treatment should be carried out. In the majority of cases no causal treatment can be of value. In leukemia extirpation of a spleen is worse than useless, being almost invariably fatal. Fixation and extirpation are possible in other cases, extirpation being the operation of choice.

DISEASES OF THE DUCTLESS GLANDS

By George Dock, M.D.

Diseases of the Thyroid Gland

GOITER

Under the term goiter we include most of the non-inflammatory enlargements of the thyroid gland. The word is sometimes used in connection with new-growths, as sarcomatous or carcinomatous goiter, but this usage is not considered a good one. Practically, however, it is often difficult or impossible to distinguish between goiter and benign adenoma. Goiter may be general, affecting all parts of the gland, or partial, affecting a lobe or part of a lobe—the right more frequently than the left. Such terms as substernal, submaxillary, retropharyngeal, and intratracheal goiter explain themselves. Goiters vary in size from a barely perceptible enlargement to a voluminous mass hanging far down below the neck, and weighing many pounds. Goiters are rarely congenital. Usually they develop about puberty or during early middle life, but may begin earlier or later. Sporadic cases occur in all parts of the world. Epidemics have sometimes been observed, especially where many people have been living under similar conditions of crowding, and only rarely in non-goiterous districts. Goiter appears most frequently as an endemic, in many parts of the world, sometimes affecting a large proportion of the population,—25, 50, or even 75 per cent., as in parts of Switzerland. In many localities in Michigan about 10 per cent. of young girls have goiters, usually not large enough to cause serious inconvenience. Women are more frequently affected than men, in the proportion of two to one, or sometimes higher. Of the numerous etiologic factors of goiter, heredity, congestion, and drinking-water are most often alleged. The former has probably been overrated on account of the endemic occurrence. Congestion is probably an assisting cause, as enlargement of the thyroid has often been noticed after congestions, as by carrying loads on the head, constricting the neck, etc. The relation of drinking-water is most important, but the condition of the water causing the goiter is wholly unknown to us. However, it is practically certain that no ordinary chemical element is concerned, and the exciting cause is most likely an infection. The anatomic condition of the gland varies considerably in goiter. Clinically, we can distinguish: (1) A diffuse hypertrophy, in which either adenoid hyperplasia (parenchymatous) or colloid change may predominate, or in which enlargement of the ves-

sels may warrant the use of the term vascular, which is anatomically misleading, since the vascular change does not occur alone; (2) fibrous goiters, which are very rare; (3) circumscribed goiter, in which adenoid or colloid change may predominate; (4) cystic, in which true or false cysts may occur, often associated with hemorrhagic, fibrous, calcareous, and other degenerations; (5) various forms of adenoma.

Goiters usually develop slowly, but acute cases have been observed in which the gland has reached considerable size in a few hours. The usual course is characterized by variations in size, with or without apparent cause. Spontaneous disappearance is rare in goiters of long standing, but sometimes occurs in acute cases. During the course of the disease the chief manifestations are usually local. The pressure of the mass causes in different cases, and at different times, numerous and varied symptoms, such as congestion or cyanosis of the head, headache, stridor, dyspnea, sometimes asthmatic in character, paralysis or spasm of the vocal cords, palpitation, and irregularity of the heart. In some cases respiratory symptoms are most important, either from pressure on the trachea from without or from intratracheal growths. Death may thus be due to goiters. Chronic tracheitis or bronchitis or emphysema may be secondary to the irritation of the trachea, and may in time lead to dilatation of the heart, with its sequels. Pain in the posterior auricular nerve may be caused by pressure, and pressure of the spinal accessory branches may cause irritation of the trapezius and sternocleidomastoid muscles. Narrowing of the pupil, vasomotor disturbances of the head, as well as exophthalmos may be present from irritation of the sympathetic nerves. Dysphagia is often present, varying from slight discomfort to complete obstruction. Large goiters sometimes affect the facial muscles so as to give the patient a stupid expression, and this is sometimes associated with mental weakness, epilepsy, and deaf-mutism.

Treatment.—Although we have no treatment for goiter directed, so far as we know, to the exciting cause, we have some different indications depending upon the variety present. Careful investigation must, therefore, be made in order to determine the predisposing causes, the exact topographic features, and, as nearly as possible, the structure of the goiter.

Prophylactic Treatment.—In persons who are likely to have a predisposition to goiter, or who already have a distinct enlargement of the gland, congestion should be avoided as far as possible. Drinking-water derived from a goiter district should never be taken unboiled. In many cases the use of boiled water or a change of water will check the development of a goiter. Removal from an endemic focus is sometimes necessary. All unhygienic habits or practices should be corrected in goiterous subjects, and all external unhygienic conditions should be removed. In endemic foci bad water is not the only thing to be attended to.

Medicinal Treatment.—Goiter has a medicinal treatment that is, in a certain degree, specific—viz., iodin. This has long been used, originally in the form of burnt sponge or inhalation of iodin from sponge. The use of iodin was begun by Coindet in 1820. Since the physiologic importance of the gland has been known, and especially since the discovery of iodin in the thyroid by Baumann, more exact observations have been made. The rationale is still unknown, but certain facts are fairly well established. A. Kocher* has recently discovered certain relations between the efficacy of iodin and the excretion of that substance by the urine. Thus, in patients with diffuse hyperplastic goiters iodin excretion is greater after the ingestion of that drug than in healthy persons. In these cases the goiter subsides under treatment. In the case of nodular goiters, or partly colloid or mixed goiters, the excretion is as in healthy persons, and the goiters do not improve under treatment. In colloid goiters the iodin excretion is increased, but the goiters do not subside. Kocher finds that goiters that decrease under iodin contain relatively little of that element, and vice versâ.

Mode of Use.—Iodin has been used externally, painted over the gland, or in cataplasms or ointments, internally, and by injection into the goiter. In general, the internal administration is best, but if there are objections to it, solution of potassium iodid (10 to 20 per cent.) can be used on compresses allowed to remain over night. The tincture has been used by painting with it over the goiter, and is often effective in small and recent goiters, but should never be continued long enough to discolor the skin.

Internally, iodin with iodid of potassium or sodium may be used in dose of 3 grains a day, after meals, as in Lugol's solution, 15 to 20 drops three times daily. If a goiter can be affected favorably by iodin, the result usually appears very soon. In order to prevent the unpleasant or dangerous results of the drug, its effects should be carefully watched. It is safer to give it every other day, and if, after a few days, no effect is visible, it should only be continued as an experiment requiring careful supervision. In all such cases it is important to exclude the existence of cysts by careful palpation or, if necessary, by exploration. Very often a goiter that seems to be parenchymatous at first will decrease slightly under treatment, and we can then discover that a cyst is present, or several cysts, that obviously cannot be benefited by internal treatment. The use of large doses of iodin is to be avoided on account of the danger of so-called iodin marasmus, characterized by emaciation, palpitation of the heart, and weakness, sometimes ending fatally. In many cases this condition is more properly called thyroidism, mentioned later.

Injections.—Iodin in various forms, when injected into goiters, exerts its specific action, and also a purely local or irritative effect. Necrosis, followed by connective-tissue growth, occurs, with sec-

* Ueber die Ausscheidung des Jods, etc., Mitth. aus den Grenzgeb., 1905, xiv, 359.

ondary contraction. Colloid matter is not absorbed as the result of the injections. The advantages of the method are nil, while the dangers are real and serious. Numerous cases have occurred in which death has followed a parenchymatous injection. Abscesses are not uncommon. Iodoform, alcohol, and other substances used by injection have all the dangers of iodin and no advantage. Recurrences are not uncommon, and although in some cases injections have produced improvement after other methods failed, yet the injections are universally regarded at present as unscientific. Operations are more difficult in cases previously treated by injection.

Organotherapy.—It was discovered (Reinhold, 1894) by the treatment of goitrous insane with thyroid preparations, that the goiters sometimes improved. Since then, and especially since the discovery of Baumann, thyroid tablets or iodothyrin have been used to a very large extent. In general, the results are like those that follow the administration of iodin, but no better. The explanations of the action of organic preparations are interesting, but not necessary to detail here. The gland or its active principle may cause an atrophy of the tissue that had become hypertrophied in order to compensate for the goiterous portion—a sort of atrophy from non-use. Certain disadvantages have been noted, especially the occurrence of frequent pulse, headache, and other symptoms of Graves' disease. Some of these cases have been attributed to the use of decomposed material. Though thyroid extract has no advantage over iodin, it may be given in small goiters of recent origin for a short time, in doses of from 1 to 6 tablets a day. Larger doses have been used, but are not safe. Iodothyrin, the active constituent of thyroid gland, discovered by Baumann in 1895, has no advantage over well-made dried thyroid, but may be used in doses of 1 to 2 grains three times a day. If results are not visible in two weeks, the remedy should be abandoned.

The use of thymus, as originated by von Mikulicz, reveals some interesting facts. In some cases goiters that have not reacted to thyroid extract have decreased under thymus, in doses corresponding to 15 grains of raw gland three times a week.

Goiters that do not subside under iodin or thyroid or thymus products come under consideration as surgical problems.

THYROIDISM

This term is given to a condition sometimes seen in the operative or medicinal treatment of goiter. Its causation is most reasonably explained by a change in the quality and quantity of thyroid secretion, in a sensitive constitution, as in neuropathic persons, or those with disease of the heart. Not all cases reported under the name of thyroidism have been due to gland secretions. Some have doubtless been due to poisons resulting from putrefaction. The symptoms are much like those seen in Graves' disease. Many cases reported under the name iodism in former days were really cases of thyroidism,

due to rapid absorption of toxic substances from the goitrous gland, as Lebert suggested in 1862.*

THYROIDITIS—STRUMITIS

Inflammation of a normal thyroid gland is rare; strumitis, or inflammation of a goitrous gland, is relatively frequent. Follicular and cystic goiters are most frequently concerned. The process is often assisted by traumatism, such as contusion from blows or attempts at strangling; congestion, as occurs in child-birth; carrying heavy loads upon the head, etc. The exciting cause is infection, either direct, as in the use of an unclean needle in exploring or carrying out treatment, from general infection, or by metastasis from a focus in some other part of the body. Diphtheria, typhoid fever, malaria, influenza, pneumonia, erysipelas, scarlet fever, measles, variola, orchitis, mumps, and puerperal sepsis are the diseases most frequently concerned. The cases formerly described as due to rheumatism or cold can easily be ascribed to bacterial infection. In Illoway's case the thyroiditis followed a pharyngitis with arthritis, and while the primary disease may have been rheumatism, the "enormous amount of pus" in the gland speaks more for infection with pus-organisms from the pharynx. The discovery of colon bacilli in one case, with no other history than that of constipation, suggests an explanation for certain otherwise obscure cases. Pneumococci, streptococci, and staphylococci, typhoid and pyocyaneus bacilli have also been found.

The anatomic changes are those of inflammation in various degrees. In the exanthemata mild processes occur. In others the process may go on to purulent infiltration of the connective tissues and among the epithelial cells, and finally necrosis. The process may be diffuse or circumscribed, single or multiple.

The clinical features are pain in the neck, radiating in different directions, soon followed by chill and fever. The neck swells, sometimes with great rapidity, according to the seat of the inflammation, becomes painful, tender, red, hard, and elastic, and later it may give fluctuation. The cervical veins are enlarged. Headache, delirium, nose-bleed, and alteration of the voice up to aphonia may be present. Dyspnea is common, and may be due to pressure on the trachea or spasm of the glottis from pressure on the recurrent laryngeal nerves. Difficulty in swallowing may be intense. Motion of the head is painful; pressure on the tracheal and cervical plexuses may cause pain, paresthesia, or even paresis of the upper extremities.

Resolution may follow in a few days, or suppuration (60 to 70 per cent. of cases) or gangrene may ensue. The termination is fatal in about one-fourth of all cases. When softening occurs, rupture may take place externally or into the larynx, trachea, esophagus,

*See especially A. von Notthafft, Ein Fall von artificiellem akutem thyreogenem Morbus Basedow, Cent. f. inn. Med., 1898, xix, 353.

or mediastinum. The common carotid artery has been eroded by the process. Suppurative strumitis in a case of Graves' disease has, however, been (Troizki) followed by healing of the abscess and recovery from the other symptoms, and, on the other hand, acute thyroiditis has been followed by Graves' disease. In some cases of suppuration the process is very chronic. In the case of cystic goiter the cyst may be dissected out by the suppuration. Gangrene is a rare outcome, and though dangerous, may end in recovery.

Treatment.—In the beginning treatment follows general principles, no matter what the exciting cause may be. Cold in the form of an ice-bag or coil should be used, the pain relieved by opiates, and the general condition treated with reference to previous or coexisting diseases. Suppuration must always be suspected, and efforts made to detect it at the earliest moment by careful palpation and the cautious use of the exploring syringe. Large doses of salicylates may be used before this, or parenchymatous injections of pure carbolic acid, as advised by Kocher. As soon as suppuration is detected, the treatment should follow surgical principles.

EXOPHTHALMIC GOITER

(Parry's Disease; Graves' Disease; Basedow's Disease)

Our knowledge of the nature of Graves' disease is still chaotic. The theory most widely held at present is that of Moebius, according to whom the process is due to excessive and altered thyroid function—to "hyperthyroidism" and "dysthyroidism." This theory is based on several facts: The clinical picture of Graves' disease resembles the symptoms caused by intoxication with thyroid substance; the disease presents, as it were, the reverse of the clinical picture of myxedema, in which the function of the thyroid is diminished or suppressed; partial resection of the goiter causes a diminution or cessation of the symptoms. The failure of all other explanations hitherto advanced has also a good deal to do with the acceptance of Moebius' theory. But it seems irrational to try to explain the pathology of such a condition as a well-marked case of Graves' disease by the morbid action of a single organ. Though we may admit that the most prominent and earliest symptoms of the disease may be best explained by thyroid intoxication, we must bear in mind the strong tendency on the part of the ductless glands to multiple involvement. When one is affected, another is likely to be affected, not only in function, but anatomically also. While the medullary, sympathetic, and other theories are insufficient to account for the disease, we can hardly doubt that the functions of certain parts of the central nervous system, the sympathetic nerves, as well as the gastro-intestinal tract, genital organs, and many others, are often involved in varying degrees. Though the neuropathic basis is not always as distinct as some have maintained, individual peculiarities

of constitution have much to do with the reaction to such noxa as are present in Graves' disease.

The disease is more frequent in females than males, in the proportion of at least 5 to 1. It is most frequent between the ages of fifteen and forty, but children and older persons are not exempt. After forty the proportion of men is relatively larger than before. The disease has been known to affect members of two or three generations in a family. It is said, and also denied, that Graves' disease is more frequent where endemic goiter occurs. Fright and mental shock, chlorosis, pregnancy, various uterine anomalies, and pelvic diseases of women are associated with Graves' disease in many cases, but the relations are by no means clear.

The principal anatomic changes are: (1) A diffuse hyperplasia of the thyroid gland, with proliferation of epithelium and diminution of normal colloid, the follicles containing a mucinoid substance; the vascularity is usually increased. (2) Hypertrophy and dilatation of the heart, with fatty degeneration. (3) A severe fatty degeneration of the voluntary muscles, evidently toxic in origin. In addition, the orbital fat is increased; the lymph-glands, thymus, and spleen often show lymphoid hyperplasia. The parathyroid glands are perhaps degenerated in all cases, but do not play an important part in the pathology, as was once believed.*

The course of the disease is so variable that it is difficult to classify all cases. Some begin acutely and die in a few days (peracute cases) or weeks. The term acute has been given to all cases fatal within six months. Others begin acutely and recover rapidly, or, what is more frequent, become chronic. The majority of cases develop slowly and remain chronic for long periods, with variations of all symptoms both in severity and presence. Chronic cases sometimes become suddenly worse and die with acute symptoms. The division into primary and secondary cases is not very useful. Primary cases are so called when the goiter appears with or after some of the other chief symptoms. Secondary cases are those in which a goiter has existed before the others appeared. But the goiter is often small and overlooked by the patient. In most cases carefully examined it is the first sign. A more useful classification is that of "complete" cases, in which the cardinal symptoms of goiter, tachycardia, exophthalmos, and tremor occur, and "incomplete" ("formes frustes" of the French) cases, in which one or more of these is absent. In both forms the secondary symptoms, psychic, nervous, vasomotor, muscular, gastro-intestinal, genital, and others, occur in varying force and number. Tachycardia is never absent all through the course of the disease.

About 10 per cent. of cases die directly as the result of the disease, usually from heart failure, either suddenly in syncope, or after signs of loss of compensation, with edema, albuminuria, etc. Sometimes death is due to general weakness, to exhaustion from intract-

* See W. G. MacCallum, Med. News, October 31, 1903, and April 8, 1905.

able vomiting or diarrhea, with mania, or with symptoms of intoxication. Some cases die from complications, such as pneumonia or tuberculosis. About 30 per cent. of cases recover almost completely. Usually some traces, as irritable heart, vasomotor neurosis, goiter or muscular weakness, remain. Graves' disease has been followed by myxedema. In every case the prognosis is serious in proportion to the severity and number of the symptoms. The best guides to improvement are the pulse-rate and the weight; next to those, the lessened nervousness, ability to sleep, and increase of strength. The prognosis is more serious in men, though recoveries occur. The risk of pregnancy has been asserted and denied. It doubtless varies in different cases. I have seen it completed in several cases, always without damage. In all cases but those with peracute symptoms the prospects for improvement are good.

Treatment.—As usual in a disease so obscure in its pathology, so chronic in its course, and so variable in the severity and combination of its many symptoms, innumerable methods of treatment have been advocated for exophthalmic goiter. Very many of these methods have been based upon conceptions of the disease not yet demonstrated to be well founded, and while many of them have been followed by improvement, none are wholly satisfactory.

Treatment based upon the conception of Graves' disease as a hyperthyroidism and dysthyroidism obviously suggests removal of as much of the diseased gland as is safe, with regard to the well-known consequences of total removal. This part of the subject is discussed on page 860. Without attempting to enter upon the merits of the surgical question, I feel that it will be long before even a majority of patients will permit operative treatment. It is, therefore, proper to consider the non-surgical treatment at length.

Thyroid Preparations.—On the supposition that Graves' disease is due to altered thyroid secretion, the experiment of giving healthy thyroid seemed proper and was begun comparatively early. Cases were very soon reported in which either benefit or no harm resulted, also others in which the characteristic symptoms became worse. If, in some cases, this did not occur, it was natural to assume that the preparation used was inert, and that any good that followed in other cases was due to other measures. It is still undecided whether thyroid is devoid of all beneficial action in exophthalmic goiter. It is conceivable that the administration would be useful in cases where altered secretion is chiefly at fault, but if the symptoms are due to excess of normal secretion, more could only do harm. Careful experiments might profitably be carried out in order to determine this point.

Thymus, used with benefit by Owen in the erroneous belief that he was using thyroid, and also by Mikulicz and many others, seems to have a good effect on the symptoms and deserves further observation.

Ovarian extract, extract of pituitary body, and adrenal prepara-

tions have all been used. The two former have not been used enough to warrant a conclusion. Adrenalin, which might be supposed to act like digitalis, besides having some other possible effect, has not given very encouraging results, judging from the literature. It has failed in a number of cases I have seen treated with it, and although in these cases the dose may not have been carried far enough, the dangerous secondary effects of the drug make it an undesirable agent for further experiment.

More promising fields of organotherapy have been opened up by Ballet and Enriquez, Moebius, Lanz, Burghart, and others. Ballet and Enriquez injected serum obtained from dogs from which the thyroid had been removed, and got improvement of the tremor, exophthalmos, and goiter. Burghart injected serum from a case of myxedema, also with advantage. Later he used serum and its products from thyroidectomized dogs. From these experiments grew the "antithyroidin" of Moebius, the serum of sheep deprived of their thyroid glands six weeks before the first serum is taken. It is preserved with 0.5 per cent. carbolic acid, and with proper care lasts indefinitely. With this serum Moebius, Schultes, and many others have obtained favorable results.* The serum is best given internally, in doses of 0.5 to 15 grams a day, in wine usually. Improvement has been noted after from 30 to 120 grams have been taken. All the subjective and objective symptoms improved. Intermittent treatment seems most certain to combine benefit and safety.

O. Lanz modified the method by using the milk of thyroidectomized goats. This has led to the production of a dry preparation, under the name of "rodagen," at the suggestion of Burghart and Blumenthal. "Thyroidectin" is the name given to another blood preparation. With all these preparations numerous cases have been treated, and the reports so far published are favorable—in some cases very much so. On the other hand, it is too soon to expect unfavorable reports. My own observations have not convinced me the preparations are specifics, and we still need information not only as to the mode of action, but also as to dosage, mode of administration, and possible untoward results. O. E. Lademann,† who used milk of thyroidectomized goats, found good results only as long as he gave the milk, as happened in some cases treated with the serum. He suggests that the milk merely neutralizes the poison, and is not really antagonistic to the disease itself. Moebius ‡ thinks that the good effects of large doses of antithyroidin may be maintained by small doses. If this is confirmed, it will render the method less irksome than it now seems.

Rogers and Beebe have done much experimental and clinical work with sera prepared by inoculating rabbits or sheep with extracts from

* See Alexander, Behandl. des Morb. Basedow, etc., Münch. med. Woch., 1905, No. 29.

† The Treatment of Basedow's Disease, with Report of a Case, Amer. Med., Nov. 19, 1904, p. 886.

‡ Ueber das Antithyroidin, Münch. med. Woch., 1903, No. 4.

human thyroids removed from patients with exophthalmic goiter. The results are interesting, but it is too early to draw conclusions as we can from cases treated symptomatically or surgically.*

Careful observations upon patients treated with these or similar preparations, and accurate pharmacologic study of the remedies themselves, are very desirable.

Treatment based upon the symptoms may be carried out in the mean time, with the knowledge that many cases have, under this method, so far recovered as to be practically well.

The first essential in the treatment is rest. This is indicated by the tachycardia, the muscular weakness, the nervous irritability, and some other symptoms. The degree and kind of rest, however, require careful selection for each individual. In all cases where the symptoms are severe the patient must be in bed, with all the sedative and supporting features of the Weir Mitchell treatment. and must remain there until distinct improvement has been secured. Even in mild cases it is often useful to carry out treatment for a longer or shorter period in a hospital, in order to teach the patient some of the details. In ordinary chronic cases this is not necessary, but rest should be taken by long hours for sleep, by lying down in the daytime, and by excluding avoidable physical and mental work as much as possible. In the case of patients who cannot avoid some work, it is a good plan to insist on the reclining position always when another is not necessary. For the housewife, this is much more useful than directions to go to bed part of the day, usually involving climbing stairs and changing the clothing, and, on the whole, secures considerable rest. Besides avoidable work, all so-called relaxations involving muscular or nervous strain must be so arranged as not to be harmful. Churches, women's clubs, literary or musical societies, reading, dancing, and games of all kinds must be prohibited if their attendance or cultivation make any of the symptoms worse. All physical exercise must stop short of a feeling of fatigue. The advantages of fresh air must be secured by rest out of doors, protected from drafts and rain or snow, as long as possible every day.

The diet should be as full and nutritious as possible, but at the same time plain, varied, and appetizing. If necessary, food should be taken between the principal meals or on retiring. Every effort should be made to increase weight, but never at the risk of bringing on indigestion. The regular action of the bowels should be provided for.

Regular bathing, adapted to the patient's strength, should be practised. If sufficient exercise cannot be taken, massage may be useful.

Besides overwork, all other injurious habits or practices should be prohibited. Tea, coffee, and tobacco should not be used. Alcoholic drinks are not necessary, but the milder ones may sometimes be used as stomachics or sedatives. Cocoa, chocolate, malted milk,

*See especially Archives of Internal Medicine, 1909, iii, 298–329.

and broths may be substituted for the other beverages. Emotional shocks, strains, and perversions should be guarded against. Excitement in any form should be avoided.

If the mode of life outlined above is carefully followed, great improvement and even recovery often follow without resort to any other treatment. Often, however, certain symptoms require other measures.

Tachycardia is best treated by rest, and should never be treated by drugs without rest. If the pulse-rate and the overaction of the heart do not improve sufficiently after a day or two in bed, cold should be applied by the use of the ice-bag, which is preferable to the coil or to compresses for this purpose. The ice-bag should not be heavy; the ice should be finely cracked. It should be applied on the skin, or with one or more layers of cloth between it and the skin, according to the patient's sensations. Many patients keep the ice-bag on day and night with benefit. Others become nervous, and the ice-bag should then be kept on for short periods, with an interval of a quarter to half an hour between.

If within a few days the pulse does not reach a fairly good rate,—less than 100,—or if there is unusual dilatation of the heart, a cardiac tonic, such as digitalis, strophanthus, or strychnin, should be used, with careful attention to the effect or non-effect of the drug. I have obtained better results from strophanthus and strychnin than with digitalis in such cases, but have always used the ice-bag at the same time. In cases with extreme cardiac derangement and incompensation, digitalis should be tried.

The nervousness and inability to sleep should be treated as much as possible without drugs. In order to promote sleep a comfortable bed and a cool and well-aired room are most useful. The lower extremities should be kept warm, if necessary by a hot-water bag, hot brick, or the like. A hot drink of milk, cocoa, or malted milk just before retiring is often beneficial. In some cases a bath at 96° to 98° F., fifteen or twenty minutes, assists in quieting the nervous system and promoting sleep. If there is much nervous irritability after trying these measures, a dose of bromid of sodium, 40 to 80 grains, in plenty of water, should be given in the evening. This is probably better than the pure hypnotics, which may sometimes be necessary as emergency drugs, and of which sulphonal, veronal, and trional may be mentioned. Neither these nor the bromid should be given regularly.

Special attention should be given to the gastro-intestinal tract. Stomach symptoms of all degrees, from the mildest to the dangerous crises, should receive careful attention. Daily enemas or mild laxatives are often beneficial, for even if we cannot accept the belief of W. H. Thomson that the disease is a gastro-intestinal intoxication, there can be no doubt that constipation is often distinctly harmful. It is probably for this reason that the regular use of sodium phosphate is beneficial, and not on account of its action on the

medulla, as imagined by Trachewsky. The gastro-intestinal crises of the disease probably result from an effort on the part of the organism to excrete poisons. Far from checking the excretions, it is more rational to aid them, by washing out the stomach, giving active cathartics, and using colonic flushings. At the same time supporting measures should be used—stimulating food, strychnin hypodermically, sometimes subcutaneous or intravenous saline injections.

Anemia in Graves' disease does not always indicate special treatment, and iron is often given needlessly, with the result of doing harm rather than good. Thorough examination of the blood should be made in every case, and if considered proper, iron, arsenic, or other remedies given.

Fever sometimes occurs in Graves' disease, but must not be supposed to be present in every case in which a feeling of subjective heat or a flushed skin occurs. When there is fever, search should always be made for complications—tuberculosis of the lungs especially. If the cause of the fever cannot be discovered, mild symptomatic treatment is usually sufficient. In more severe cases tepid or cold sponging or cold packs may be used.

Urticaria and circumscribed edema should be treated as under other conditions.

Anatomic alterations of the uterus may require special treatment. Anomalies of the nose and pharynx should be treated as when they occur independently. Occasionally recovery may follow some one of these operations. Ulcer of the cornea is a serious complication, demanding special treatment. A bandage over the eyes at night is useful in protecting the cornea in cases with great exophthalmos.

Glycosuria (alimentary) and diabetes mellitus or insipidus have often been observed. The treatment should follow the principles laid down in general for these diseases.

Some other methods of treatment may be mentioned.

Change of climate is often beneficial for patients with Graves' disease. No special climate can be prescribed for all cases. For some the mountains, for others the seashore, for others inland places at moderate elevation may be recommended, according to disposition and convenience. The essential features are that the patient shall not feel or exhibit an aggravation of any of his symptoms. Sea-bathing is dangerous for such patients. Warm sea-water baths are usually beneficial. Systematic hydriatric treatment has sometimes been useful.

Electricity has been much used in the treatment of Graves' disease, and many cures have been ascribed to it. No specific directions seem possible for such treatment, for the method found valuable by one is condemned as useless by others. It is probable that most of the benefit in Graves' disease, under electricity, is due to suggestion, and from this and many other results in the treatment

of this disease the physician can gather a useful hint as to the value of hope, and of assurance of recovery, no matter what other measures are used.

Iodin has been widely used in Graves' disease, in various forms, and with very different results in different cases. The goiter is often reduced, and in some cases improvement has followed. The former may be explained by the ordinary effect of iodin on part of the goiter; the latter by checking an excessive secretion. On the other hand, many cases have been reported in which alarming symptoms, formerly spoken of as iodism, but now recognized as symptoms of thyroid intoxication, have occurred, and especially when iodin had been given in large doses or injected into the gland. The external use of the drug has been least dangerous in this respect. Iodin should, therefore, not be used without due care in Graves' disease, but careful experiments for the purpose of showing the actual part played by iodin seem legitimate. Iodothyrin is in the same category as iodin and thyroid preparations.

Roentgen rays have been used in the treatment of Graves' disease, as well as that of ordinary goiters. The experiment is an interesting and important one, but one with serious possibilities of harm. Not only the immediate results, but also the ultimate effects, of the treatment should be carefully observed and recorded. From the known effects of Roentgen rays on epithelial as well as lymphoid tissue a marked change is to be expected when the thyroid and parathyroid glands are exposed. From the reduction of the goiter, in this way, improvement of some of the symptoms is to be expected. It can be determined only by experiment whether this will be more beneficial to the patient than reduction by iodin or intrathyroid injections. If the effects are as severe as they sometimes are in lymphatic glands treated by *x*-rays, it is probable that contraction and retrograde changes will be set up by too intense treatment that may hasten the change, sometimes observed, from Graves' disease to myxedema.

Of the numerous "new" methods of treating Graves' disease it is not necessary to speak in detail. As in the case of older drugs, coincidence and accident have much to do with the bases on which they are recommended. As an example may be mentioned antidiphtheric serum, as recently reported: A woman with exophthalmic goiter had diphtheria. She was given 1500 units of serum. Four months later the goiter had disappeared, the pulse-rate was normal, nervous symptoms absent, but "the eye symptoms were a trifle better." Another woman with a goiter and a pulse-rate of 120 was given two doses of 2000 units of serum ten days apart. The pulse fell to 82. Five months later the patient was "perfectly well," though she still had the goiter and the eye symptoms; the latter "improved." It should be added that the author of the report suggests that the diphtheria toxin may have had some influence in the first case. Experiments are much needed in order to perfect our

methods of treating Graves' disease, but critical observations are essential to real advance.

MYXEDEMA AND CRETINISM—ATHYROIDISM

Three distinct clinical conditions, each with certain varieties, represent the complete or partial failure of the thyroid secretion. These are cretinism, myxedema, and cachexia strumipriva or thyreopriva. From the standpoint of therapeutics, it is convenient to consider them together.

Cretinism is an arrested development, physical and mental, with dystrophy and deformity of bones and soft parts. It is sporadic in all parts of the world, and endemic in certain parts of central Europe, especially in Switzerland and the neighboring Alpine countries, the foci being the same as those of endemic goiter. The exact cause is not known. In sporadic cases such predisposing causes as trauma and fevers are often given, but are obviously unsatisfactory. An alteration of the thyroid is always present. In endemic cretinism goiters prevail. In the rest of the cases the thyroid is atrophied. In sporadic cretinism goiter is rare, atrophy being the usual change. Other important changes in the body are: Retarded growth of bones, with infantile traits remaining in the proportion of the various parts; late closure of sutures and fontanels; deformity of the skull, especially in endemic cretinism; changes in the skin like those in myxedema (hence the name, infantile or juvenile myxedema); imperfect development of the genitals. The intellect is defective, though less so in sporadic than in endemic cases. The face is puffy or bloated; the skin dry, hair thin; the eyelids, nose, tongue, and lips thickened; teeth late in appearing and tending to caries; the abdomen large; the extremities clumsy.

The disease may be congenital, but more frequently begins to show itself in the first year of life or by the end of the second or third year. The course is chronic. In endemic cretinism the patient may live to fifty years or more. In sporadic cases, unless treated, life is rarely prolonged to the thirtieth year. Death is due to intercurrent disease, such as nephritis, pneumonia, or other acute infectious disease.

Under thyroid treatment a remarkable improvement occurs, both physical and mental, though the subjects never become perfectly normal. The preventive treatment of endemic cretinism is one of the duties of humanity that will probably have to wait until many other tasks of a similar kind have been performed. The specific treatment will be described with that of myxedema.

MYXEDEMA

Myxedema is characterized by dystrophy of the skin, with alterations of various physical and mental processes, due to loss of function of the thyroid gland. The exciting cause is not known. As

predisposing causes, numerous things have been described, such as emotional strain or shock, tuberculosis, syphilis, and other infectious diseases, loss of blood, persistent vomiting, repeated child-bearing, prolonged lactation, the long-continued use of iodin. It has been known to follow exophthalmic goiter. There is often a history of the same disease in a mother, aunt, or some other relative. Eighty per cent. of cases occur in women. It is most common in the fifth decade, next in the sixth, but may occur earlier or later. It seems to be more frequent where goiter is not endemic—that is, where the infantile form or cretinism is common.

The process in the thyroid is chiefly atrophic. Inflammatory changes are relatively slight. The course of the disease is usually very slow, but in rare cases it is acute or temporary. The first thing that is noticed is usually the alteration of the skin, which may be mistaken for edema. The psychic disturbances soon follow, but may be overlooked for some time. The skin becomes thick, brawny, dry, and rough. It does not pit on pressure. Local increase of subcutaneous tissue occurs in certain parts, as the supraclavicular and jugular fossæ. The hair becomes brittle and falls out. The skin is cool, the body temperature below normal, and the patient becomes very sensitive to cold. The pulse is infrequent and weak. The eyelids, nose, lips, and extremities become large. The intellect progressively becomes weaker. Loss of memory, irritability, delusions, and hallucinations become gradually more constant and pronounced. Speech is slow as the result of both central and peripheral disturbances. The menses and sexual functions are altered, but sterility does not always occur. Hemorrhages from various mucous membranes and in the skin are not uncommon. Albuminuria, glycosuria, and hematuria sometimes occur.

The disease may last for many years—ten, fifteen or even thirty—if not checked by treatment. Death is sometimes due to marasmus, more frequently to intercurrent disease or complications. Complete recovery cannot be looked for in cases with severe psychic degenerations. In others, especially if there is some thyroid tissue remaining, the prospects are good.

Cachexia strumipriva is also spoken of as operative myxedema. It follows total or almost complete removal of the thyroid gland, or the destruction of the gland by suppuration. Not every case in which total extirpation is practised develops myxedema. Incomplete cases or negative cases are to be explained by the presence of accessory thyroid tissue, which may undergo compensatory hypertrophy. An important part of the pathology and symptomatology of the condition is related to the absence of the functions of the parathyroid glands.

The **symptoms** do not always begin at the same time after removal or destruction of the gland. Sometimes they appear in a few days; at others, not for months or years. The course is usually more stormy in early life. It begins with a feeling of fatigue and weakness,

often associated with pain in the extremities and a feeling of coldness. Mental alterations like those of myxedema soon follow. Edematous swellings then occur, at first temporary, often most distinct in the morning, and later permanent. If the loss of the thyroid occurs before growth is completed, the latter process is checked.

The prognosis is not absolutely bad in chronic cases. The treatment is the same as in non-operative cases.

Treatment.—The most important part of the treatment of cretinism and myxedema is the physiologic one, by supplying the thyroid secretion. The discovery of this method is one of the most brilliant results of medical investigation on biologic lines. It is impossible to give the history of the subject in full here. Suffice it to point out that Bircher, in 1889, transplanted a piece of human goiter into the peritoneal cavity of a girl with severe cachexia strumipriva. The immediate result was striking, and although a relapse occurred, another implantation was followed by improvement going on to complete recovery. Horsley had independently proposed a similar operation, with the thyroids of monkeys or sheep, and numerous operations were carried out, with many good, and some unsatisfactory results.

On account of the dangers and inconvenience of the operations, other methods were proposed, such as the subcutaneous injection of extracts of thyroid gland, the names of George R. Murray, Brown-Séquard and d'Arsonval, and Vassale being the most important in this part of the work. Feeding with thyroid glands, raw or cooked, was next proposed (Fox, Mackenzie, and Howitz, 1892).

Dried extracts of the glands were then introduced, and also dried thyroid gland itself, using the thyroids of sheep. It has been shown by very extensive experiments that most of the products are effective and free from risk of accidental infection. At the same time care should always be taken to be sure the preparation used is fresh and made by a responsible firm. "Thyroid extract," "thyreoids," and similar names represent different quantities of gland in different makes, sometimes weight for weight, sometimes less, so that 1 grain of tablet may represent 5 grains of gland. It is hardly necessary to say that the amount of gland should always be known in using such preparations, since we have no more accurate measure of the activity of the preparation.

Iodothyrin of Baumann has been used with good results, the beginning or normal dose being 15 to 40 grains a day. Other preparations representing the active principle, such as the thyreoantitoxin of A. Fränkel, the thyreoglobulin of Oswald, have been used with good results.

The method of treatment with any preparation and in all forms of athyroidism is in general the same. It consists in getting the full effect of the thyroid as soon as possible, with the avoidance of unpleasant or dangerous symptoms. If one preparation does not cause distinct improvement in a few days, or at most two weeks, another should be

tried. Some cases do better on one preparation than others. Feeding with the fresh glands of sheep or calves, raw or cooked, may be practised when possible, but the freshness of the glands must be beyond doubt. Sandwiches made of finely chopped thyroid are taken by some patients without difficulty. Most patients find the tablets or capsules less disagreeable.

The good effect of the treatment appears in the improved condition of the skin, temperature, mind, and all other symptoms. The weight, in myxedema, is lowered, menses reappear, hair grows. In cretinism the long bones grow, sometimes rapidly, sometimes long after the usual period of growth has been passed. Even in endemic cretinism specific treatment is sometimes successful.*

Not only does the dose have to be discovered by careful observation, but unpleasant or dangerous results of the treatment must always be looked for, and, when they occur, checked by stopping the treatment altogether or lessening the dose. In some cases small doses, one 2-grain tablet a day, have been followed by rapid pulse, fulness of the head, anginose pain in the heart region, faintness, even sudden death, as in the case of Foulis, in which profuse fatal diarrhea followed the first dose of ¼ lobe of thyroid in twenty-four hours. Large doses are likely to cause pain in the back and extremities, tremor, palpitation of the heart, tachycardia, weakness, sometimes collapse. Urticaria and other skin affections sometimes occur. It is better to begin with small doses, corresponding to about 2 grains of the fresh gland, and to increase gradually, stopping the increase at intervals in order to prevent the sudden absorption of a large dose. New symptoms should cause the immediate cessation of treatment and the careful observation of the patient.

After improvement has been brought to the best possible point, the dose should be decreased. The amount necessary in such cases can be fixed only by trial. Larger doses are usually necessary in cold weather. In general, the individual need and tolerance can be fixed, and treatment, which must be for life, then carried out without much difficulty.

The general dietetic and symptomatic treatment of myxedema requires attention in all cases. Numerous experiments have proved the dangers of excessive meat diet in such cases. The diet should, therefore, be largely vegetable, with milk.

It is not necessary to speak of the symptomatic treatment in detail. An important feature is the sensibility to cold, which should be guarded against by warm clothing or removal to a warmer climate. Symptoms occurring from thyroid treatment may be treated as when they occur under other conditions. After the accidental symptoms have subsided, the thyroid should again be given. The myxedema patient in time learns to recognize the symptoms of the disease, and also those of an overdose of the remedy.

* A. Magnus-Levy, Ueber das Myxoedem, Zeit. f. klin. Med., Bd. vi, p. 201.

Diseases of the Adrenal Bodies

ADDISON'S DISEASE

Addison's disease is due to loss of the internal secretion of the adrenal glands or other parts of the chromaffin system, and is characterized clinically by muscular weakness, feeble heart, gastro-intestinal irritation, and pigmentation of the skin and mucous membranes.

That the symptoms depend upon loss of function of the adrenal glands is no longer doubted by many. All other theories leave much more to be explained than does the one mentioned. In 88 per cent. of cases some alteration of the adrenals is found. For the others, a functional disturbance is supposed. Cases of adrenal disease without characteristic symptoms can be explained partly by the greater rapidity of their course, leaving no time for the development of the symptom-complex, or by the vicarious action of accessory adrenal tissue, very often present in the body.

The most frequent alteration is tuberculosis, either miliary, fibrocaseous, or fibroid. In a small proportion of cases there is either simple atrophy, chronic inflammation, malignant disease, or hemorrhage. Other changes, such as those in the sympathetic ganglia and nerves, are secondary. There are often persistent thymus, enlarged spleen, and hyperplasia of the gastro-intestinal lymphoid tissue.

The disease is more frequent in males in the proportion of 3 to 1. The period of life from twenty to fifty years is most often affected, but infants and octogenarians have not escaped; about 50 cases have been reported in persons under sixteen years of age. Among assisting causes traumatism and hemorrhage into the adrenals at birth have been advanced. Tuberculosis of the adrenals in Addison's disease is often primary.

The course of the disease is usually chronic, lasting from one to three years in most cases. Much longer periods—up to ten years—have been reported, and acute cases have been observed in which death occurred in a few weeks. Sometimes the clinical course is short, but the lesions may have all the evidences of long standing.

Weakness is usually the first symptom—both muscular and cardiovascular. Gastric or intestinal irritation is generally irregular or paroxysmal. Acute cases have been known to follow severe medicinal purgatives. The pigmentation develops slowly or rapidly, and sometimes reaches an intense degree. The course is sometimes remittent, especially in cases of long duration. Recovery has been reported, but the probability of error in diagnosis is very great in such cases. Death is usually due to asthenia. It may occur from syncope, from tuberculosis in other organs, from debility caused by vomiting or diarrhea, or from a toxic condition, with convulsions, delirium, and coma.

Treatment Based upon the Adrenal Theory.—On the theory of

loss of internal secretion, adrenal gland and its extract have been applied, and also the blood-pressure raising principles isolated by Abel and others. The gland or simple extracts would seem more promising than adrenalin and its congeners, but clinical and experimental proof may alter this view. In many cases improvement has been noted. Edward W. Adams* has examined the reports in 97 cases and found no effect in 43; 31 temporarily and 16 permanently improved. Three died early in the treatment. It is impossible to tell in advance what cases will do well under treatment.

The best method seems to consist in getting the patient under the physiologic effect of the substance and keeping this up with smaller doses. The blood-pressure should be observed before and during treatment. Fifteen grains of gland or its equivalent in powder or tablet, three times daily, have been given in the beginning, increasing to 120 grains, and these doses have been taken without bad results. On the other hand, alarming symptoms sometimes follow, such as fever and depression, and death has occurred soon after beginning treatment.

Boinet † has used adrenalin, beginning with $\frac{1}{3}$ milligram. Even this small dose may be too large in some cases. Out of 8 cases, 6 were improved after an average of 220 injections. Two died in a few days after treatment was begun. Boinet warns against giving the treatment in advanced cases. The longer the treatment is continued, the smaller should be the dose and the longer the free intervals. He suggests that the oxyadrenalin, only one-tenth as toxic as adrenalin, may be better.

Many therapeutists and physiologists admit that adrenalin is efficient when given by the stomach, but this requires further and careful investigation.

Treatment Directed to the Cause of the Adrenal Disease.—Tuberculin has been used in the treatment of Addison's disease, apparently without definite results. It must be remembered that the clinical diagnosis of tuberculosis of the adrenals cannot be positively made from the symptoms. A tuberculin reaction may be fallacious by reason of a latent focus somewhere else. Even if there are tubercles present, it is doubtful whether there would be any advantage in using tuberculin, since secondary sclerosis or atrophy would go on as usual. Owing to the hopelessness of the disease at present, however, careful diagnostic and therapeutic use of tuberculin is legitimate but dangerous. It could be combined with organotherapy.

Symptomatic Treatment.—With or without specific treatment, symptomatic treatment of Addison's disease is necessary. Weakness should be treated by rest, in bed if necessary. The body should be kept warm. The food should be mild, nutritious, and easily digestible.

* Results of Organotherapy in Addison's Disease, The Practitioner, October, 1903, p. 471.

† La Médication surrénale dans la maladie d'Addison, Bull. de l'Acad. de Méd., 1904, vol. lxvii, No. 39.

Constipation should be guarded against by diet and by mild laxatives. Severe purgatives should be avoided. Diarrhea should be treated by large doses of bismuth; vomiting, by ice pills and champagne. Strychnin, arsenic, and various tonics have been used with apparent advantage. In using any treatment, it is important to remember the variable course of the disease and the seeming influence of suggestion with reference to new methods.

Disease of the Pituitary Body

ACROMEGALY

Acromegaly is closely associated with disease of the pituitary body, but the alterations reported by various observers have been interpreted so differently that it is still uncertain just what the true relation is. The more careful investigations point to a primary disease in the pituitary body, and indicate that the distinctive anatomic lesion is, as Benda suggested, an increase of the chromophile cells.* Alterations are frequently found in the thyroid gland, sometimes atrophy, more often enlargement, with increase of colloid and other changes.

The disease affects both sexes equally, on the whole, but more women after forty. One-half of the cases begin between twenty and thirty, none before fourteen or fifteen. Rheumatism, syphilis, and specific fevers, sometimes thought to be causes, probably have no relation to acromegaly. Fright and other emotional strains seem more difficult to exclude as causes, but if effective, must leave very much to other causes.

The course is essentially chronic. Acroparesthesia, pain in the bones and extremities, headache, tendency to fatigue, apathy, and in women cessation of menstruation accompany the beginning, followed by abnormal growth of the skull and bones of the extremities, as well as the soft parts. Deformity of the vertebræ, optic neuritis, optic atrophy, and bitemporal hemianopsia often occur, the latter sometimes early. During the existence of the disease exacerbations and remissions may occur. The latter occur without reference to treatment, the patient sometimes being able to resume work. The longer the early stages of the disease, the greater is the prospect of long and slow later course. Death is sometimes sudden, occasionally from coma in diabetes, a rather frequent complication, sometimes from bronchitis, pneumonia, or tuberculosis. Cases have been classified as acute, lasting three to four years; ordinary, including most of the cases, up to thirty years; and benign, lasting up to fifty years.

Treatment.—Treatment based on conceptions of the morbid process has hitherto been disappointing. Operative treatment has been

*See especially Dean D. Lewis, Hyperplasia of the Chromophile Cells of the Hypophysis as the Cause of Acromegaly, with Report of a Case, Johns Hopkins Hosp. Bull., May, 1905, p. 157.

quickly fatal. Pituitary glands and extract have not produced definite improvement.* The same may be said of thyroid treatment, which has often appeared to make the symptoms worse.

Symptomatic treatment should be supporting in the first place. Polyphagia and glycosuria indicate dietetic treatment. Constipation often requires treatment. Potassium iodid has been used with seeming benefit in a few cases, and also mercury, by inunction, even in cases that did not seem to be syphilitic. Arsenic has also been used with apparent benefit. Headache requires the use of analgesics, but depressing remedies, like the coal-tar derivatives, must be used, with due regard to the frequent cardiac weakness.

*See Kuh, Sidney, Treatment of Acromegaly with Pituitary Bodies, Jour. Amer. Med. Assoc., February 1, 1902, p. 295.

THE SURGICAL TREATMENT OF DISEASES OF THE THYROID AND PARATHYROID GLANDS

By Joseph Colt Bloodgood, M.D.

In diseases of the thyroid gland the most interesting medical aspects are their relations to hypo- and hyper-thyroidism. Hyperthyroidism with its thyreotoxic symptoms may be present from a lesser degree up to the complex clinical picture of exophthalmic goiter or Graves' disease. Hypothyroidism may also manifest itself in various degrees up to the definite picture of myxedema. Cretinism is but a term for congenital myxedema.

The treatment of thyroid lesions is practically surgical. Certain forms of goiter, cysts, and adenomas of the thyroid are removed because of their local symptoms—size, deformity, pressure symptoms. All thyroid lesions as well as the typical exophthalmic goiter, on account of the hyperthyroidism, should be given the benefit of surgical intervention at the proper time. The medical treatment alone has but a narrow field. When hypothyroidism or myxedema is present, the administration of thyroid extract usually acts in a specific way. Patients suffering with symptoms of hyperthyroidism should have a period of absolute rest before they are subjected to operation.

THYROIDITIS

Acute Thyroiditis.—De Quervain,* who has made the most extensive contributions to thyroiditis, recognizes two types—the toxic, in which the changes are chiefly in the parenchyma (liquefaction of the colloid and desquamation and degeneration of the epithelium), and the infective, in which bacteria are present in the thyroid tissue, and in which, in addition to the changes in the parenchyma, there are found in the stroma the usual histologic picture of acute inflammation, which may proceed to suppuration.

Until there is evidence of pus formation there is apparently no indication for surgical intervention. Up to this time the treatment should be symptomatic. Apparently the best local application is ice. In some instances if there are signs of tracheal obstruction one should operate before signs of abscess develop, dividing the thyroid through its isthmus and relieving the trachea of pressure. Infective thyroiditis, especially with suppuration, is a sign of grave general infection, and is often fatal, especially when there is a complication of typhoid fever.

Atrophy of the thyroid is more apt to follow infective thyroiditis,

* Mittheilungen a. d. Grenzgeb. d. Med. u. Chir., 1904, Supplement, and 1905, xv, 297.

with or without abscess formation, than toxic thyroiditis, and many of the cases of myxedema in children and adults which have developed without operation on the thyroid gland can be accounted for only on the supposition of an atrophy secondary to an infective thyroiditis. I have observed exophthalmic hypertrophy to develop after the toxic thyroiditis of a chancroidal infection, and myxedema after an acute infective thyroiditis, without abscess, associated with influenza.

Apparently we have no means of preventing thyroiditis in the infectious diseases and toxemia, nor any means of reducing the probabilities of hypertrophies or atrophies. It seems to be the consensus of opinion that during the thyroiditis iodin should not be employed either internally or externally. There seems to be evidence that this increases the probability of exophthalmic hypertrophy ensuing.

Tuberculous Thyroiditis.—Tuberculous thyroiditis is rare,* and the probabilities are that the lesion will not manifest itself until abscess formation takes place. Then the surgical indications are clear. The surgeon, therefore, in exposing a cystic tumor of the thyroid and finding pus, should attempt to distinguish between the pyogenic (probably post-typhoid) and the tuberculous abscess. For the latter partial thyroidectomy may be indicated; for the former simple incision and drainage.

Syphilitic Thyroiditis.—Benjamin F. Davis,† in recording a case of his own, summarizes twenty cases reported in the literature. He calls attention to the swelling of the thyroid gland so frequently observed in secondary syphilis. It is difficult to determine whether this swelling is toxic and due to the syphilitic virus, or due to the use of potassium iodid.

Syphilis of the thyroid manifests itself as a gumma, a painless tumor suggesting cancer, because of the infiltration beyond the thyroid to the trachea and larynx. As a rule, the skin is uninvolved. As with gumma elsewhere, there may be ulceration. If the lesion is not quickly subjected to treatment, there may be destruction of the entire thyroid gland, with myxedema. Although gumma is rare, this lesion should always be considered in those swellings of the thyroid with infiltration outside its capsule. A Wassermann reaction should be taken, and it is my opinion that an exploratory operation should be performed in every case. It can do the individual with cancer no harm, and in the syphilitic gumma it would make the diagnosis at once, pressure symptoms could be relieved by partial thyroidectomy, and the early employment of dioxydiamido-arsenobenzol (Ehrlich-Hata) would probably prevent thyroid atrophy and myxedema.

* According to von Schiller (Zentralbl. f. Chir., 1909, xxxvi, 326) only six cases have been reported as observed in the living subject. I have observed a tuberculous abscess in a patient suffering with multiple suppurating tuberculous glands of the neck, and in an exophthalmic goiter removed by Halsted, Lambert discovered in the gross two gray areas, which under the microscope proved to be tuberculous.

† Arch. Int. Med., 1910, v, 47.

SIMPLE GOITER

As stated in the introduction, we are chiefly interested in the relation of thyroid enlargements with and without thyreotoxic symptoms. The indications for treatment, both medical and surgical, are much more urgent when thyreotoxic symptoms are present.

We may employ the term simple goiter to distinguish that type of thyroid hypertrophy which involves, to a certain degree, symmetrically the entire gland, and with which there are slight or no symptoms of hyperthyroidism. In addition to simple goiter there are asymmetrical tumors of either lobe or the isthmus which are true adenomas or cysts. These tumors may be present with or without symptoms of hyperthyroidism.

What are the indications for operative intervention in simple goiter, cysts, and adenoma of the thyroid without symptoms of thyroid intoxication?

At puberty and during pregnancy there is an enlargement, normally, of the thyroid gland. This may be excessive, and we may speak of puberty hypertrophy and pregnancy hypertrophy. If there are no other symptoms, there is no indication for partial thyroidectomy unless the thyroid enlargement produces pressure symptoms or reaches a sufficient size to justify its removal on account of the deformity. If physicians are given an opportunity to observe carefully the onset of simple goiter, secondary to either puberty or pregnancy hypertrophy, or when these factors are not present, no individual should be allowed to suffer a simple goiter to reach any considerable size. After the thyroid enlargement has reached a certain size, one lobe should be removed. If the remaining lobe continues to grow, it should be partially removed. I am confident, therefore, that the deformity of the neglected simple goiters is an unnecessary one. Just when surgery should interfere cannot be expressed in any fixed terms. But after the thyroid hypertrophy has reached a size that it may be looked upon as a distinct deformity, it should not be allowed to go further.

In the small cyst and adenoma observed in individuals under thirty —and these may have the same relation to puberty and pregnancy as the simple goiter—there is no indication for their removal unless they reach a sufficient size or produce pressure symptoms. They may disappear. When these tumors have not disappeared after the individual has reached thirty years of age, or if they appear after thirty years of age, it is my opinion that they should be immediately removed. The operation for the removal of a cyst or adenoma of the thyroid is simple, practically free from danger in expert hands, and the scar is less of a deformity than the tumor. The object of this operative intervention in individuals over thirty is definitely to prove that the asymmetrical nodule is not malignant. Experience has shown the great tendency for malignant changes later in life in the benign adenoma and cyst. When the malignant tumor can be recognized

clinically, on account of its infiltration beyond the capsule, experience has shown that the disease is hopeless. To cure cancer, therefore, of the thyroid we must operate at once on apparently innocent nodules which appear in the thyroids of individuals over thirty, and also remove those which have appeared earlier in life, but have not disappeared when the patient has reached thirty. I have already presented the evidence to justify these statements.*

Thyroid Extract.—When an individual has symmetrical or asymmetrical enlargement of the thyroid gland, it is customary to give thyroid extract. In an earlier period the gland was painted with iodin and iodin was given internally.

If the individual is suffering with a thyroid lesion associated with hyperthyroidism, these thyreotoxic symptoms will be increased, and if they were not very pronounced before, the stimulation of the thyroid extract will intensify them. If the lesion of the thyroid is associated with hypothyroidism, there will be distinct improvement in the condition of the patient, and often a moderate decrease in size of the thyroid hypertrophy. I have observed in both simple and exophthalmic goiter such variations in the size of the thyroid enlargement and in the symptoms that I am somewhat skeptical of the value of thyroid extract in simple goiter. As a therapeutic test it is helpful in some cases. When there is hypothyroidism with any of its symptoms, the value of the drug at once shows itself.

EXOPHTHALMIC GOITER

My experience with exophthalmic goiter is chiefly surgical, but I have observed numerous recoveries without operation under various methods of treatment. In certain regions of Pennsylvania enlarged thyroids with typical thyreotoxic symptoms are not uncommon, and recovery without operation has been observed in a large number of cases. I find, however, that it is impossible to get at the relative proportion of recoveries to the fatal cases. On the other hand, my experience from the surgical treatment of this disease becomes more satisfactory as the number of cases increases and the time since operation grows longer. I am unable, therefore, to speak of any treatment of exophthalmic goiter, except one which includes among its measures partial thyroidectomy.

Medical Treatment.—In so many cases of Graves' disease a psychic factor can be recognized as the cause that in the medical treatment this must be borne in mind. It is quite true that the hypertrophy may be secondary to physiologic hypertrophy—puberty and pregnancy—and represents an example of an excessive reaction to a normal stimulant. The relation of the pelvic organs to the thyroid at puberty must also be borne in mind, and, now and then, one will be able to accomplish a cure by dilatation and cureting to establish the menstrual periods, or to make menstruation less distressing if it is established.

* Surg., Gynec. and Obst., 1905, i, 113, and 1906, ii, 121.

Now and then pregnancy will have to be terminated because of the gravity of the thyreotoxic symptoms. I have observed a patient whose first hypertrophy followed the death of her parent; she was relieved by the removal of the right lobe, but married within three months. With the onset of pregnancy, six months after operation, the symptoms returned, and after a few months the pregnancy had to be terminated. The greatest test of the result of partial removal of the thyroid for exophthalmic goiter is a subsequent pregnancy. In one of my cases after two years of freedom a pregnancy did not excite a return of the disease. The hypertrophy may be secondary to a thyroiditis. The prognosis of partial excision seems best in this group.

In the medical treatment any etiologic factor which is still active must be removed if possible. We can in a certain number of cases at puberty relieve menstrual discomfort; pregnancies can be terminated. But when the hypertrophy is secondary to some preëxisting disease of the thyroid gland, we are unable to reach this factor. In all of the cases there is a psychic factor. These patients at once need some change in their environment which will give them absolute mental rest and confidence. In the more grave cases there should be absolute rest in bed; in a hospital, if possible.

The treatment which gains the confidence of the individual and relieves of fear and anxiety produces the best results. If this is arranged to be associated with rest and proper diet, the physician has established a treatment which in some instances will accomplish a cure; in all it is the best treatment preliminary to operative intervention.

At the present time, it is my opinion that even in slight cases, and even in those in which there is considerable improvement under the successful rest treatment, operation should be performed. When this is done, the individual has undoubtedly saved time, and there seem to be fewer recurrences than in patients who have been apparently cured by medical treatment alone. The more severe the thyreotoxic symptoms and the less change they show under medical treatment, the more urgent becomes the operation. If these patients are seen early and physicians really perform their duty in diagnosis and treatment, the surgeon should never be called upon to institute surgical procedures in the late and very serious stage of the disease.

Drugs.—As far as I am able to ascertain, the effect of any drug is psychic. If the patients are anemic, iron is indicated, etc. I have faithfully tried the various preparations of quinin recommended in alternate cases. It is a good plan, however, to administer some drug constantly, telling the patient that it is of curative value.

Diet.—This depends upon the symptoms. In some cases the diet must be confined entirely to liquids, and now and then kefir, koumyss, or buttermilk are good substitutes for ordinary milk. The elimination should be increased by water, guarded catharsis, and bathing of the skin.

x-Rays.—Theoretically the *x*-rays should do harm in exophthalmic

goiter, because they increase the vascularity of the tissues. I notice in the literature very little in favor of this method of treatment in recent years. The results at first obtained can undoubtedly be explained on their psychic value. A recent patient of my own was very much relieved temporarily by a quack who told her that the disease was due to the torpidity of the spinal cord, and that he could relieve it by pounding the back with his fist.

Serum.—I am not sufficiently familiar with this method of treatment either to favor or to condemn it. In four cases under my observation the patients had received the serum treatment under the best environment. A second treatment after a recurrence failed. These patients were relieved by operation. Their recovery was slow. I can therefore discuss only the medical treatment which recognizes and treats the psychic factor chiefly. Any means may be employed to get the confidence of the patient and to allay fear and anxiety. This should be combined with rest, regulated diet, and fresh air. The toxic factors of exophthalmic goiter must be recognized in the medical treatment by drugs and methods which increase elimination.

Surgical Treatment.—It is an art today to choose the proper time for surgical intervention. When the operation is performed in slight cases, the dangers are so decreased that the surgeon may be crude in presenting the operation to the patient, not particularly skilled in the technic, and the method of anesthesia may be unskilful; yet the result will be a good one. As the symptoms of hyperthyroidism increase and the toxemia becomes more intense and the toxic heart more feeble, the dangers of operative intervention increase. To these very ill patients even the suggestion of an operation may exaggerate the symptoms. The factors of safety grow smaller and smaller against narcosis and operative manipulation. The chief cause of death is acute dilatation of the heart.

In the more critically ill individuals the first thing to do is to ligate one artery, or two arteries on one side. If the improvement is marked, perform removal of that lobe. If the improvement is less marked, ligate the arteries on the other side. The object of ligation of the arteries is to reduce the circulation to the thyroid gland, and theoretically to reduce absorption of its secretion. Practically improvement does follow ligation of the artery, and this method of treatment has a distinct place as a preliminary to thyroidectomy.

In all cases the operation should be presented to the patient in such a way that fear and anxiety are reduced to a minimum. Crile proposes to steal the gland by letting the patient smell some aromatic vapor every morning, and then suddenly substituting ether, so that the patient never knows there is even to be an operation. I have not found this necessary, but its principle is sound. I think the operation can be presented in such a way that the danger will be no greater than the additional danger of Crile's method dependent upon the longer anesthesia taken up during the transportation of the patient to the operating room. I prefer to delay the anesthetic until the

patient is cleaned up and ready for the operation. There still seems to be a difference of opinion among authorities as to the choice of the anesthetic—local, ether-drop, or nitrous oxid and oxygen. I prefer the ether-drop method given during the skin incision only; for the remainder of the operation scarcely any anesthetic is needed.

For a few days preliminary to operation I employ ice to the heart and neck. After the operation this is continued, and the patient is given water by the mouth, the rectum, and subcutaneously. After the operation, morphin is indicated for restlessness. I have been unable to see any value in heart tonics.

The chief source of fatality after operation is dilatation of the heart. This complication may come on during the operation or shortly after it. The patients operated upon who survive two or three days generally recover. In one of the patients operated on by Halsted a direct blood transfusion seemed to be the factor which tided over death.

In the very critically ill patients success in each case depends upon attention to the most minute details in the medical treatment, in the surgery, and in the nursing. Undoubtedly increased experience with these cases shows itself in a greater number of recoveries. Triumphant as success in these critical cases is, such tests of the surgical art are unnecessary. Exophthalmic goiter can and should be recognized in its earlier stages at a period in which both medical and surgical treatment are comparatively simple, and the results proportionately better.

In some cases of simple goiter, or after operations for any of the different thyroid lesions, there may be contraction of the operative scar with symptoms of obstructed respiration. In this group of cases the only indication is an operation, not to remove more thyroid tissue, but to relieve the trachea of its compression. This operation is called endothyreopexy and has been most recently summarized by Tavel.* It consists, first, of freeing the thyroid tissue from the trachea, and in those cases in which some thyroid tissue is to be removed, the arteries should be preliminarily ligated; then the thyroid is to a certain extent mobilized, dislocated forward, and fixed to one side into a pocket between the sternocleidomastoid muscle and the skin.

In some cases it might be necessary to so dislocate and mobilize a small substernal nodule which is obstructing breathing on account of its position. In such cases the enlargement of the thyroid is not sufficient to indicate lobectomy. In other cases the lateral enlargements are fixed by chronic inflammation of the capsule, and the isthmus produces the pressure upon the trachea. In a case of this kind I have obtained a result by division of the isthmus without endothyreopexy. In other cases, in which respiratory symptoms followed as a late complication the removal of one lobe, I have been able to relieve the symptoms by separation of the scar tissue between the trachea and the remaining lobe, partial removal, mobilization of

* Deutsche Zeitschr. f. Chir., 1910, cvi, 391.

the remaining thyroid tissue, but without the dislocation recommended by Tavel in his endothyreopexy. The operation, however, seems to have a distinct place in a small group of cases.

CRETINISM AND MYXEDEMA

The fully developed disease due to absence of thyroid secretion in the newborn (cretinism) or later in life (myxedema) is not at all difficult to recognize. The symptoms of the milder degrees of hypothyroidism are much more difficult to recognize and are frequently overlooked. In some cases within large thyroid glands, the symptoms of hyper- and hypo-thyroidism are difficult to differentiate, and in a few cases it would appear that the patients are affected with the absence of the normal secretion (hypothyroidism) and the presence of a toxic secretion (hyperthyroidism). The clinical picture of the earlier and less distinct cases of cretinism and myxedema are by no means established, nor the relation of these symptoms to the pathologic changes in the thyroid gland. In all doubtful cases the best therapeutic test is the administration of thyroid extract. In children who show faulty development of the skeleton, thyroid extract should be administered early. Bircher* and Laewen† have illustrated the changes of the skeleton in cretinism.

Partial or complete myxedema is observed at any time in life after puberty. In the more obscure cases nervous phenomena predominate, and in women at the menopause there may, in addition, be excessive hemorrhages at or between the menstrual periods. Pitfield‡ describes his experience with these misdiagnosed and mistreated examples of partial myxedema.

In all patients with obscure nervous symptoms, headache, falling out of the hair, increase of fat in the supraclavicular fossa, dryness of the skin, changes in mental capacity, etc., the therapeutic test, at least, of the thyroid extract should be employed. Recent literature has a number of interesting contributions demonstrating the importance of this therapeutic test in doubtful cases. In myxedema, in addition to thyroid extract, general massage seems to have a good effect in relieving the patients of the discomforts of poor circulation which may be associated with edema.

Surgical Treatment.—With good surgery post-operative myxedema should be a very rare occurrence. Its possibility must be borne in mind, however, because even in partial thyroidectomy the remaining portion of the gland is subject to the same influences as the gland in non-operative patients, and, in addition, there is the possibility of circulatory changes due to the scar tissue. Cases with huge goiters of the simple type may be slightly myxedemic before operation and show increase of the symptoms after partial thyroidec-

* Centralbl. f. Chir., 1909, xxxvi, 1079.
† Deutsche Zeitschr. f. Chir., 1909, ci, 454.
‡ Amer. Jour. Med. Sci., 1909, cxxxviii, 92.

tomy. I have observed, in a few cases of multiple fetal adenoma occupying most of the thyroid gland, evidence of myxedema after partial thyroidectomy. In these cases the patients have so little normal thyroid outside of the multiple fetal adenomas that partial thyroidectomy produces a condition of hypothyroidism. This is often temporary.

As soon as it had been demonstrated that myxedema and cretinism were dependent upon the absence of thyroid secretion, organic therapy suggested itself, and also the possibility of transplantation of thyroid tissue from animals of the same or different species. Von Eiselsberg was one of the first to transplant thyroid tissue into thyroidectomized animals successfully. It was demonstrated in animal experiments that the greater the need of thyroid secretion, the greater the probability that the transplanted piece of gland will become vascularized and function. This is also true in the experience with transplantation of the thyroid in the human being. Gruneberg,* from his experience with myxedema, especially the cases of lesser degree, is of the opinion that the results of the administration of thyroid extract are so satisfactory that thyroid implantation will become necessary in only a few cases.

My personal experience with myxedema has been very small, but up to the present time it agrees with that of Gruneberg. I found it a good plan to vary the dose from time to time, to stop it now and then for a week or two, and every three to six months to get thyroid extract from some other manufacturer.

Hans Salzer† and von Bramann‡ review the literature and bring the question of transplantation of thyroid up to date. In the first place, there is no harm in trying it in any case if the subcutaneous method be employed. Apparently the best results are obtained in the more pronounced cases of myxedema and cretinism. Successful cases have followed implantation in the subcutaneous or preperitoneal tissue of the abdominal wall, first advocated by Christiani; in the marrow cavity of the tibia—Kocher's method. So that apparently it is not necessary, at least at first, to follow the more difficult technic of Payr and transplant into the spleen. These transplanted pieces of thyroid tissue do become vascularized and do function, but they may later atrophy. So that repeated transplantations are often necessary. The field of transplantation of thyroid tissue is but in its experimental stage.

THE PARATHYROID GLANDULES AND TETANY

The accumulated experimental and clinical evidence of very recent years has practically proved the relation between total extirpation of the parathyroid glandules and destructive diseases, on the one hand,

* Centralbl. f. Chir., 1910, xxxvii, 80.
† Archiv. f. klin. Chir., 1909, lxxxix, 881.
‡ Centralbl. f. Chir., 1910, xxxvii, 140.

and the clinical picture of tetany, on the other. Tetany may vary in its intensity as does myxedema. For the lesser degrees of tetany Halsted has introduced the term "subtetanic hypoparathyrosis."

As in myxedema, so in tetany, we must look for and recognize the milder types of these conditions which are associated with the thyroid gland or parathyroid glandules. In both post-operative and non-operative tetany the earlier recognition would lead to the immediate treatment with the calcium salts, the freshly prepared parathyroids from animals, the commercial tablets, or, in more desperate cases, the transplantation of parathyroids from other human beings.

Post-operative Tetany.—The most important part of treatment here is prevention. In a careful dissection for the usual disease of the thyroid of the benign type, injury or removal of the parathyroid glands is an avoidable accident. In the dissection of the thyroid gland the thyroid vessels should be ligated near, and if possible within, the capsule of the thyroid. The posterior capsule should be preserved. If a dissection is carried out along these lines, there is little danger. After the removal of the thyroid specimen the surgeon himself should make a careful search for the parathyroids on the specimen. If they are present, they should immediately be detached with the most careful dissection and implanted in the most vascular tissue of the neck.

My experience with carcinoma and sarcoma of the thyroid has convinced me that it is unjustifiable to attempt complete excision. The patient would run the risk of tetany and myxedema, and there would be no possibility of eradicating the malignant disease. But if a surgeon should persuade himself to make such an attempt, he should be prepared to treat both post-operative tetany and myxedema.

In secondary operations upon the thyroid when there has been a previous complete lobectomy the danger of injury or removal of the parathyroids is very much greater. In the first place, there is the possibility that the parathyroids were injured or removed at the first operation, and the patient has now only the parathyroids on the other side. One should take no risks, therefore, but ligate the vessels well within thyroid tissue and leave some thyroid tissue to the posterior capsule. The majority of surgeons prefer to leave behind the lower pole of the remaining lobe, and the inferior artery is not ligated at all. I prefer to leave both poles as an additional safeguard. After dissecting the thyroid free I divide the thyroid tissue with the Paquelin cautery, leaving a crescent-shaped piece of thyroid tissue composed of both poles with the tissue between, and some of the thyroid tissue with the posterior capsule between.

Cases of post-operative tetany have been observed in the past, and in some of these cases recovery has taken place without the aid of modern treatment. Although today post-operative tetany is a much less frequent complication than in the earlier period of thyroid surgery, yet the evidence favors the conclusion that the means at hand have accomplished cures.

The therapeutic measures are: The administration of calcium salts (MacCallum and Voegtlin*). The salt which seems most efficacious is calcium lactate. It may be given by mouth, in salt solution per rectum, and, in cases of great emergency, the first administration may be subcutaneous. The exact dose has not been established, and it seems best to give at first a great deal, at least 60 grains, or even more, in the first twenty-four hours. There should be an almost immediate effect, with improvement of the symptoms of tetany.

The patient may be given by mouth or subcutaneously emulsion of parathyroid obtained fresh from the glands of animals. The most complete presentation of the entire subject of the preservation of the parathyroid glands during operation and of the recognition and treatment of the various types of post-operative tetany is by Halsted.† The observation of Branham‡ demonstrates the apparent life-saving effect of subcutaneous injections of emulsion of freshly prepared parathyroid gland.

Danielsen§ reports a successful transplantation of the parathyroid glandules from a human being into a patient critically ill with post-operative tetany. The patient recovered. We have, however, no positive histologic proof that the transplanted parathyroid lived and performed its function. There is only the clinical evidence, but Halsted and others have shown that transplantation of parathyroid is possible in animals. Danielsen mentions three other successful cases in the literature. In all post-operative thyroid cases any symptom leading to a suspicion of tetany should at once be followed by the administration of calcium salt.

When the clinical picture is established without a doubt, the patient should receive subcutaneous injections of emulsion from parathyroids obtained fresh. According to Danielsen, the parathyroids of horses are larger and easily recognized, but freshly killed horses are difficult to obtain in this country. In any slaughter-house one should be able to obtain, as was done by MacCallum, sufficient parathyroid glandules for the immediate treatment.

In the more chronic cases and in those in which the treatment has to be kept up for a longer period of time the parathyroid preparation which can be obtained from competent druggists should be tried. This is often ineffectual.

It seems that the danger of removing the parathyroid glandules from one pole of the normal thyroid in the healthy individual is not sufficiently great to contraindicate it in special cases. Danielsen obtained the parathyroid glandules for his patient from two individuals, taking one from each individual. No one, as far as I am able to ascertain, has attempted to use the parathyroids from a fresh autopsy.

* Johns Hopkins Hospital Bull., 1908, xix, 91.
† Amer. Jour. Med. Sci., July, 1907; and Annals of Surgery, 1907, xlvi, 489.
‡ Annals of Surgery, 1908, xlviii, 161.
§ Beiträge z. klin. Chir., 1910, xxxvii, 998.

Non-operative Tetany.—The clinical picture does not differ from post-operative tetany. As a rule, it is less marked than that form of post-operative tetany in which all the parathyroid glandules are removed.

The degrees of the symptoms vary. In all cases the muscular and sensory nerves are hypersensitive; in the more critical cases there are attacks of muscular contraction without any marked irritation of the nerves when the patients are at rest. In lighter cases the muscular contractions are brought about by tapping the motor nerves. Contractions of the face by percussion over the facial nerve near the parotid (Chvostek's sign) is a pretty characteristic feature. Tapping of other large nerve-trunks may also bring about muscular contractions (Trousseau's sign). The nerves are hypersensitive to electrical stimuli (Erb's symptom). The percussion of sensory nerves demonstrates hyperesthesia (Hoffmann's symptom). It is not difficult, therefore, in a case of tetany in which there are no spontaneous tetanic convulsions to demonstrate the mechanical irritability of the nerves and muscles. As a rule, in tetany there are no mental symptoms, except in the more grave cases.

In non-operative tetany the most important etiologic factor should at once be sought for—gastric dilatation. In such cases as soon as the tetany is controlled by the treatment just outlined for the post-operative type, the gastric stenosis should be relieved by operation. I find more references to gastric tetany than to any other form of the non-operative type, and, in recent literature, many recoveries. The treatment in the other cases is the same, and the prognosis, even before the discovery of the therapeutic value of calcium salts, and the relation of the disease to parathyroid glandules, was fairly good. It should be better today. Epidemic tetanies have been described. Tetany may occur in infants and during pregnancy. It has also been observed in infectious diseases and in acute and chronic poisoning.

At the present time we cannot place the same dependence upon the commercial preparations of the parathyroid glandules as upon the thyroid extracts. For this reason in the more critical cases one should employ parathyroids from freshly killed animals. These can be administered by mouth or in emulsion subcutaneously. The quantity should be governed by its effect upon the symptoms.

Winternitz* describes two patients with acute miliary tuberculosis, observed in the medical clinic of the Johns Hopkins Hospital, who shortly before death showed symptoms of tetany. In one of the cases a tubercular focus was found in one parathyroid gland; in the other the glands were not examined. In both cases before death the convulsions were controlled by calcium salt. One patient received intravenously 4 gm. of calcium lactate in 100 c.c. of salt solution. The dose in the second case is not given. In both of these patients the protruding tongue exhibited fibrillary contractions, which is quite a characteristic feature in some cases of tetany, especially in animals.

* Johns Hopkins Hosp. Bull., 1909, xx, 269.

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